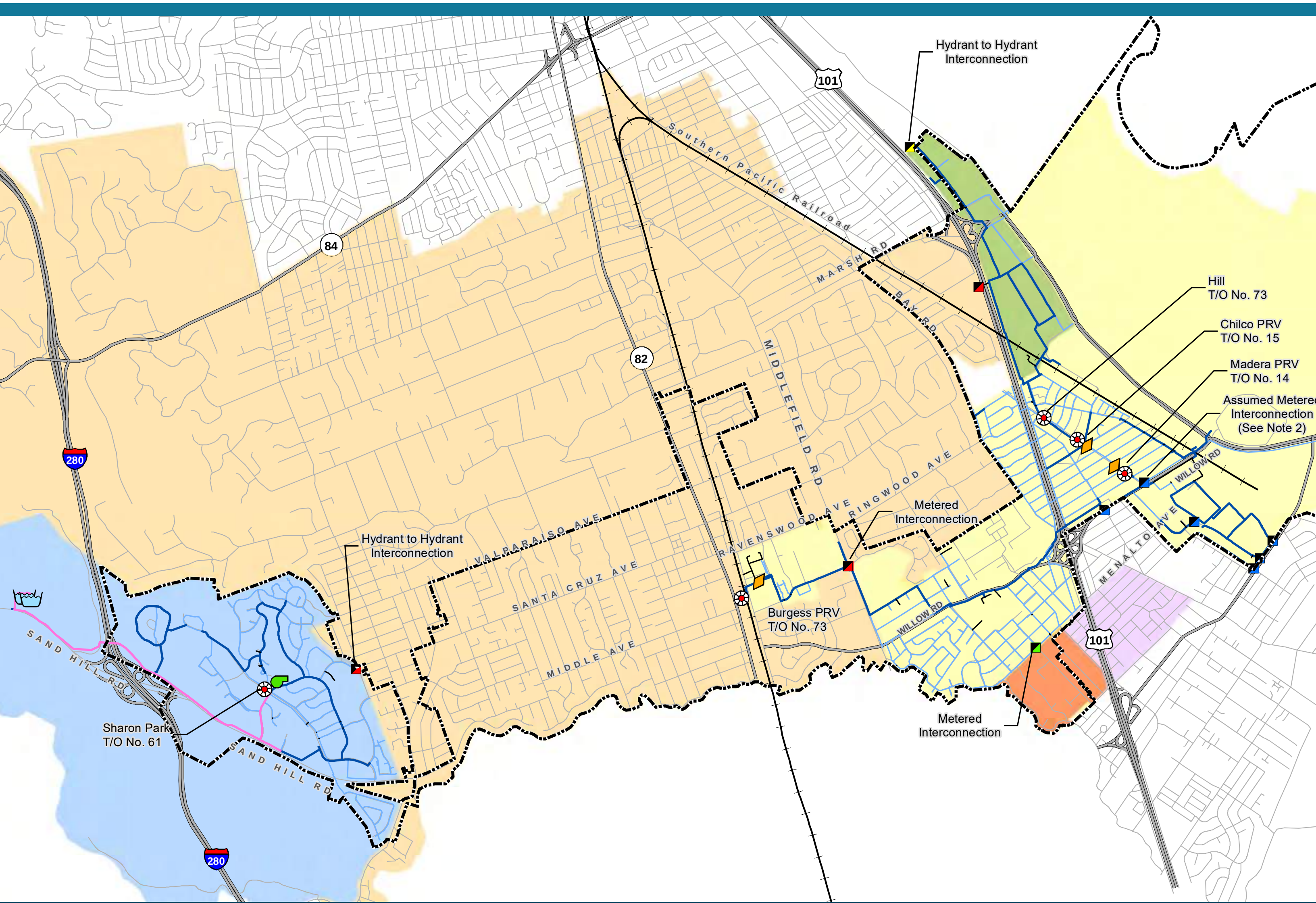
MENLO PARK MUNICIPAL WATER

Water System Master Plan

FINAL REPORT

APRIL 2018



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FINAL REPORT | APRIL 2018

Menlo Park Municipal Water Water System Master Plan

Prepared for

City of Menlo Park

Project No. 648-12-15-01

04-11-18

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List of Acronyms and Abbreviations

AB	California Assembly Bill
AC	Asbestos Cement
ADWF	Average Dry Weather Flow
AFY	Acre-feet per Year
AMI	Advanced Meter Infrastructure
AMR	Advanced Meter Reading
ARV	Air Release Valves
AWWA	American Water Works Association
BAWSCA	Bay Area Water Supply and Conservation Agency
BDPLs	Bay Division Pipelines
Cal Water	California Water Service
CEQA	California Environmental Quality Act
CFC	California Fire Code
CI	Cast Iron
CII	Commercial, Industrial and Institutional
CIMIS	California Irrigation Management Information System
City	City of Menlo Park
CMMS	Computerized Maintenance Management System

County	San Mateo County
DI	Ductile Iron
DSS Model	Demand Management Decision Support System Model
DWR	California Department of Water Resources
EBMUD	East Bay Municipal Utility District
ENR CCI	Engineering News Record Construction Cost Index
ERDI	Earthquake Resistant Ductile Iron
ERP	Emergency Response Plan
ETo	evapotranspiration data
Executive Order	Executive Order B-37-16
ft	Feet
G&CC	Golf and Country Club
gpcd	Gallons per Capita per Day
gpm	Gallons per Minute
HCF	100 Cubic Feet
HDPE	High Density Polyethylene
HGL	Hydraulic Grade Line
JPA	Joint Powers Authority
KPI	Key Performance Indicators
LF	Lineal Feet
LOS	Level of Service
MG	Million Gallons
mgd	Million Gallons per Day
MPFD	Menlo Park Fire District
MPMW	Menlo Park Municipal Water
NIMIS	National Incident Management System
O&M	Operation and Maintenance
PRV stations	Pressure Reducing Valve Stations
PS	Pump Station
PVC	Polyvinyl Chloride
PWWF	Peak Wet Weather Flow
Redwood City	City of Redwood City
rTCR	Total Coliform Rule
RWQCP	Regional Water Quality Control Plant
RWS	Regional Water System
SCADA	Supervisory Control and Data Acquisition
SEMS	Standardized Emergency Management System
SFCJPA	San Francisquito Creek Joint Powers Authority
SFPUC	San Francisco Public Utilities Commission
SLAC	Stanford Linear Accelerator Center
SOP	Standard Operating Procedures

sq	Square
SVCW	Silicon Valley Clean Water
SWTR	Surface Water Treatment Rule
TAZ	Traffic Analysis Zone
TDS	Total Dissolved Solids
UNK	Unknown
USBR	U.S. Bureau of Reclamation
USEPA	US Environmental Protection Agency
UV	Ultraviolet
UWMP	Urban Water Management Plans
VA	Vulnerability Assessment
WBSD	West Bay Sanitary District
Well 1	Corporation Yard Emergency Back-up Water Supply Well No. 1
West Yost	West Yost Associates
WSA	Water Supply Agreement
WSE	Water Supply Evaluation
WSIP	Water System Improvement Program
WSMP	Water System Master Plan

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ES.1 WATER SYSTEM MASTER PLAN PURPOSE (CHAPTER 1)

This Water System Master Plan (WSMP) for Menlo Park Municipal Water (MPMW) is a comprehensive evaluation of MPMW's distribution system. The WSMP identifies strategies for cost-effectively meeting MPMW's distribution system infrastructure needs; guides capital expenditures for the system; furnishes important guidance to enhance renewal and replacement strategies, operational and water quality practices; and provides a framework for diversifying MPMW's water supply. To accomplish these goals, the following key work tasks were performed in the WSMP:

- Evaluated and summarized existing water system and key system facilities;
- Completed a comprehensive field mapping program to update MPMW's GIS mapping of water system features;
- Prepared water demand projections through buildout of MPMW;
- Summarized existing water supplies and evaluate potential graywater use or recycled water use to provide a supplemental dry-year supply for MPMW;
- Developed and calibrated a new all-pipe hydraulic model for the MPMW system using the updated GIS water system features;
- Developed performance and operational criteria, which were subsequently used to evaluate the system and identify improvements;
- Evaluated existing and buildout water system conditions for normal operations, emergencies and water quality scenarios to identify deficiencies and needed improvements;
- Conducted a system-wide pipeline condition assessment to develop recommendations for long-term renewal and replacement program needs;
- Prepared a seismic vulnerability assessment to identify improvements to reduce system seismic vulnerabilities;
- Conducted an advanced meter infrastructure (AMI) evaluation to summarize options for MPMW to implement an advanced meter reading (AMR) or AMI program;
- Evaluated operational and maintenance activities and develop recommendations for a long-term maintenance program and for optimizing water system operation;
- Developed a capital improvement program for recommended existing and future water system facilities.

The resulting WSMP provides a comprehensive road map for MPMW for future planning.

ES.2 OVERVIEW OF THE WATER SERVICE AREA (CHAPTER 2)

MPMW is located within the City of Menlo Park (City), along the San Francisco Peninsula as shown on Figure ES-1. MPMW provides water service to approximately half of the City. California Water Service (Cal Water) provides service to the other half of the City, known as the Bear Gulch District, which roughly serves the core/middle of the City. Small portions of the City are served by the O'Connor Tract Co-operative Water Company, which provides service to 343 households, most of which are in the City; and the Palo Alto Park Mutual Water Company, which provides service to about ten (10) households.

MPMW's sole source of supply is wholesale surface water purchased from the San Francisco Public Utilities Commission (SFPUC) via the SFPUC Regional Water System (RWS). Water is supplied to MPMW via five SFPUC turnouts, and is subsequently distributed to its customers within the different pressure zones via MPMW's various water system facilities and distribution system. MPMW provides water service to approximately 4,300 residential, commercial, industrial and institutional/governmental service connections. MPMW's existing water distribution system is approximately 55 miles of water system pipelines. Pipeline diameters ranging from 2 to 18 inches in diameter, with approximately 65 percent of the distribution system between 6 to 8 inches in diameter. Most of the distribution system is comprised of asbestos cement (50 percent) and ductile iron (31 percent) pipelines.

The MPMW is comprised of three pressure zones, High Pressure Zone, Lower Zone, and Upper Zone (see Figure ES-2). The High Pressure Zone and Lower Zone are located in the northeast part of the City, along the San Francisco Bay. Though these zones are adjacent to each other, they are hydraulically isolated under normal operations. The High Pressure Zone is supplied from the SFPUC system without pressure regulation to the zone. The Lower Zone is supplied by three pressure regulating stations to reduce pressures from the SFPUC RWS.

The Upper Zone is in the southwest portion of the City, near Interstate 280 and adjacent to the Coast Range hills. It is supplied by the Sharon Heights Pump Station. Because the Upper Zone is geographically isolated, there is no direct hydraulic connection between the Upper Zone and the High Pressure/Lower Zones.

MPMW has emergency interconnections with four adjacent water suppliers: Cal Water, City of East Palo Alto, City of Redwood City, and O'Connor Tract Co-operative Water Company.

ES.3 WATER DEMANDS (CHAPTER 3)

ES.3.1 Existing Water Distribution System Use

In recent years, MPMW's annual water purchases from SFPUC have ranged from 851 MG/year (2.3 mgd average daily demand) to 1,349 MG/year (3.7 mgd average daily demand). Annual water supplies remained somewhat steady from 2001 through 2013, followed by a decline in 2014 through 2016, due to reduced usage during the recent drought.

Existing water demands were determined based on historical water delivery and detailed consumption data. Peaking factors for maximum day and peak hour demand were also developed based on historical SFPUC delivery data.

Existing water system demands used in the evaluation of the distribution system are based on MPMW's annual water purchases of 1,349 MG/year (3.7 mgd) in 2013. Water deliveries from this year were used instead of more recent years because it is more representative of normal water use within the MPMW prior to the recent drought, and accounts for typical water use patterns during normal hydrologic conditions. Existing maximum day demand is estimated to be 6.1 mgd. Peak hour demand is estimated to be 10.0 mgd.

ES.3.2 MPMW Water Conservation Programs

The MPMW has been and continues to be a strong promoter of water conservation programs that improve water supply reliability and provide environmental benefits to the community. MPMW participates in Bay Area Water Supply and Conservation Agency's (BAWSCA) regional water conservation program, which includes subscription-based programs that member agencies can elect to participate in and fund. MPMW participates in all the available BAWSCA subscription programs, including high-efficiency toilet and washing machine rebates, school education kits and programs, large landscape audits and turf replacement rebates.

For new residential and non-residential development, the City requires that all new development comply with the mandatory California Green Building Code. The City also requires that new or rehabilitated landscapes for projects subject to City review and approval comply with the City's Water Efficient Landscaping Ordinance, which reflects the latest California State Model Water Efficient Landscape Ordinance.

New development must also comply with water conservation measures stipulated in the ConnectMenlo General Plan Update 2016. New development within the Bayfront Area is required to be dual plumbed for internal use of recycled water. For buildings equal to or exceeding 100,000 square feet (sq. ft.) in size, the City requires a development of a water budget. For buildings 250,000 sq. ft. and larger, the City requires identification and use of an alternate water source for all City approved non-potable applications (e.g., graywater).

ES.3.3 Future Water Delivery Projections

In 2016, the City of Menlo Park completed a multi-year effort, called ConnectMenlo, which updated its General Plan Land Use and Circulation Elements and zoning for its Bayfront Area, which was designated as an M-2 zoning district (industrial land use) in the 1994 General Plan. ConnectMenlo established long-range planning for the Bayfront Area, which incorporates the business parks and industrial area between Highway 101 and the Bayfront Expressway.

The plan, which has a buildout planning horizon of 2040, incorporates land use changes in the Bayfront Area with development potential for up to 4,500 new multi-family residential units, 2.3 million square feet of new non-residential uses, 400 new hotel rooms and two transit centers. The Bayfront Area lies within MPMW boundaries, except for a small portion of the area, south of Highway 101, bounded by Marsh Road and the Dumbarton Rail line.

As part of ConnectMenlo, the City prepared a Water Supply Evaluation (WSE) Study, which was incorporated in the Programmatic Environmental Impact Report that analyzed the effects of the zoning changes for the portion of the Bayfront Area to be served by MPMW. Table ES-1 summarizes the MPMW service area annual water delivery projections prepared for the WSE.

Table ES-1. Projected Annual Water Deliveries

Development Plan	Projected Water Deliveries, MG/year				
	2020	2025	2030	2035	2040
General Plan Buildout[a]	1,310	1,286	1,265	1,251	1,240
ConnectMenlo[b]	0	86	172	257	343
Other Planned Projects[c]	31	31	31	31	31
Total Projected Water Demand	**1,341**	**1,403**	**1,468**	**1,539**	**1,614**

Source: Water Supply Evaluation Study

(a) Water delivery projections, as developed in the MPMW 2015 UWMP
(b) Project buildout by 2040. Phasing assumed to start in 2020.
(c) Other planned projects include the Facebook Campus Expansion and a new magnet high school.

For water master planning, it is necessary to develop spatial estimates of future demands, so that they can be applied to the water distribution system model, for the analysis of future water distribution system needs. The system analysis evaluates 2040 conditions to assess infrastructure requirements for buildout of the General Plan. The ConnectMenlo environmental impact analysis included a spatial analysis of future land use development to analyze potential traffic impacts. This analysis used traffic analysis zone (TAZ) areas to evaluate land use changes associated with ConnectMenlo. For the WSMP, the TAZ areas were refined to create water analysis zone (WAZ) areas that included modifications to TAZ areas to conform with MPMW service area and pressure zone boundaries. Once WAZ areas were defined, MPMW prepared spatial projections of future water use by WAZ.

ES.4 WATER SUPPLY (CHAPTER 4)

ES.4.1 SFPUC Surface Water

All of MPMW's water supply is purchased from the SFPUC, which operates the City and County of San Francisco's RWS, delivering treated wholesale water to Alameda, Santa Clara, and San Mateo Counties. Due to constraints of hydrology, physical facilities, and the institutional parameters that allocate the water supply of the Tuolumne River, the RWS water supply cannot always meet demands. As a result, the SFPUC has limited the volume of water that can be purchased from the RWS to 265 million gallons per day (mgd) until at least 2018. If drought conditions, emergencies, malfunction or rehabilitation of the RWS lead to a water shortage, then SFPUC's wholesale customers are subject to reduction in water supply in the amount and duration required to resolve the supply shortage.

MPMW's normal hydrologic year contract amount is 4.465 mgd, approximately 1,630 million gallons per year (MG/yr). Dry-year supply estimates developed for the MPMW's 2015 Urban

Water Management Plan (UWMP) are based on delivery estimates and application of allocation processes laid out in the most recent water supply contract. Based on these allocations, MPMW would have an estimated supply of 3.51 mgd, or 1,277 MG/yr in a single dry year, and 3.04 mgd, or 1,109 MG/yr in subsequent years following the first year of a multi-year drought.

ES.4.2 Comparison of Supply and Demand

Table ES-2 provides a comparison of supply and demand, as presented in MPMW's 2015 UWMP. The table summarizes demand in five-year increments from 2020 through 2040. As the table shows, in normal hydrologic years, MPMW is anticipated to have sufficient supplies to meet demands. However, starting in 2020 it is projected that in single-year or multi-year droughts, MPMW supply will be insufficient to meet demands. For single dry years, the shortfall is projected to be 21 percent by 2040. For multiple dry years, the shortfall is projected to be 31 percent by 2040.

Table ES-2. MPMW Comparison of Supply and Demand[a]

Demands and Supplies, MG/year	Year				
	2020	2025	2030	2035	2040
Total Projected Demand	1,341	1,403	1,468	1,539	1,614
Total Projected Supply – Normal Year	1630	1630	1630	1630	1630
Surplus or Deficit	289	227	162	91	16
Percent Shortfall	--	--	--	--	--
Total Projected Supply – Single Dry Year	**1,277**	**1,277**	**1,277**	**1,277**	**1,277**
Surplus or Deficit	(64)	(126)	(191)	(262)	(337)
Percent Shortfall	5%	9%	13%	17%	21%
Total Projected Supply – Multiple Year[b]	**1,109**	**1,109**	**1,109**	**1,109**	**1,109**
Surplus or Deficit	(232)	(294)	(359)	(430)	(505)
Percent Shortfall	17%	21%	24%	28%	31%

(a) Source: 2015 UWMP.

(b) Years shown are years two and three of a three-year drought. The first year is anticipated to have supply reductions the same as a single-year drought.

MPMW anticipates meeting shortfalls through implementation of its Water Shortage Contingency Plan, which specifies measures to temporarily reduce demand. Implementation of supply alternatives evaluated in this chapter would reduce potable water use, and thus reduce anticipated shortfalls. However, MPMW is also investigating alternative dry-year supplies. As part of the WSMP, use of graywater or recycled water were investigated.

ES.4.3 Graywater

Residential graywater is defined in the California Plumbing Code, as water from showers, clothes washers, and other domestic drains other than the kitchen sink and toilets. Although some types of residential graywater programs have been found to offer potential for substantial potable water savings, the potential potable water demand savings associated with graywater irrigation, the most likely residential type of graywater program for MPMW, has not been clearly documented in case studies.

Graywater programs for certain types of commercial facilities that produce significant quantities of gray water, such as hotels, fitness facilities, and laundromats, may lead to significant potable water demand savings for those commercial customers. Most commercial facilities, however, like offices and restaurants, do not generate enough graywater to significantly offset the potable water demand from toilet flushing or irrigation. MPMW may want to promote graywater use in commercial settings through requiring, in City code, dual-plumbing in new commercial construction to accommodate potential future graywater or recycled water use. MPMW could also focus education efforts on developers constructing new commercial facilities likely to produce a substantial quantity of graywater such as fitness centers, hotels, aquatic centers, and laundromats.

Although graywater could be a potential dry-year supply for MPMW, it is likely to have only a very small contribution in reducing potable water demands due to uncertain savings for residential programs, and limited opportunities for significant savings in commercial applications.

ES.4.4 Recycled Water

One major reason that the MPMW has not considered a recycled water program to-date is that the City does not own or operate any wastewater treatment facility and, doesn't convey its own wastewater. Therefore, any recycled water program would require coordination and various agreements with one or more agencies. The specific agencies with which the City could coordinate a recycled water program include the City of Redwood City (Redwood City), the City of Palo Alto, and the West Bay Sanitary District (WBSD).

West Yost conducted an analysis of potential recycled water options, evaluating potential areas that could be served by recycled water, estimating potential recycled water demand, developing conceptual-level layouts for infrastructure, and developing conceptual-level cost estimates for implementing a recycled water program. The WSMP evaluated service to the Bayfront Area from either Redwood City or Palo Alto. WBSD is developing a decentralized recycled water treatment facility that will supply the Sharon Heights Golf & Country Club and Stanford Linear Accelerator Center (SLAC) with recycled water for irrigation, which would reduce their MPMW potable water use.

In discussions with Redwood City, the potential costs for MPMW to purchase recycled water would likely be equal to the debt-normalized wholesale cost to Redwood City's existing recycled water customers ($2,600/acre-foot) plus a capacity buy-in fee to compensate Redwood City for its prior investments. Palo Alto could not provide an estimate of the cost of its recycled water, and is currently performing a business assessment to evaluate the cost of recycled water.

The total estimated capital cost for recycled water distribution facilities within the MPMW service area for service from Redwood City or Palo Alto was estimated to range from $12M to $13M. Conceptual-level unit water costs were estimated by converting capital costs to an annual revenue requirement and adding in anticipated wholesale costs of water. Recycled costs are estimated to be in the neighborhood of $5,000/acre-foot plus the separate buy-in fee. This compares with the current (FY 2017-18) SFPUC wholesale water charge of $1,786/acre-foot plus meter capacity fees.

West Yost recommends continuing to pursue non-potable water options, completing additional study of the Bayfront area, and continuing conversations with Redwood City and Palo Alto. MPMW should also re-evaluate dry-year supply shortages as part of its 2020 UWMP, which will develop future demand projections based on new water conservation regulations that are expected to further reduce urban water use, but for which specific methodologies are still being developed by California Department of Water Resources.

ES.5 EVALUATION OF EXISTING AND FUTURE WATER SYSTEM (CHAPTERS 5, 6, 7 AND 8)

West Yost developed a new water distribution system hydraulic model, and evaluated water distribution system performance under existing and future demand conditions to identify deficiencies. West Yost identified improvements to address deficiencies and develop a recommended capital improvement plan.

ES.5.1 Planning and Design Criteria (Chapter 5)

Working with MPMW, West Yost developed recommended planning and design criteria that were used to evaluate the performance of MPMW's water system. Criteria were developed for: fire flow requirements for new development; peak supply capacity; distribution system pressures; pump station, storage tank and pressure regulating station sizing; and water main sizing.

ES.5.2 Hydraulic Model Development (Chapter 6)

MPMW staff and West Yost developed an updated geodatabase containing the spatial location and attribute data of existing pipelines and other water facilities within MPMW's water distribution system. The updated geodatabase was based on MPMW's existing GIS and was updated using information collected during a system-wide field verification conducted by West Yost staff in late 2015. During the field verification, West Yost collected spatial and attribute information of various water system facilities, which was used to confirm water system facilities and pipeline alignments.

West Yost developed a new all-pipe water distribution system hydraulic model using the updated GIS to establish the pipeline network, and incorporating existing facilities information (turnouts, tanks, pump stations, regulating stations, zone valves) provided by MPMW. Existing water demands were allocated to the model using metered account data to distribute demands within the hydraulic model. The hydraulic model was calibrated using hydrant flow testing data collected in a field program, conducted in February 2016.

ES.5.3 Existing Water System Evaluation and Recommended Improvements (Chapter 7)

West Yost evaluated the City's existing water system facilities to identify existing deficiencies and recommended improvements. The evaluation included system capacity and performance evaluations, a seismic vulnerability assessment, a pipeline condition assessment and an advanced metering infrastructure evaluation.

ES.5.3.1 System Capacity Analysis

The system capacity analysis identified the need for new storage in the Lower and High Pressure Zone to balance the difference between supplies and demands. No other supply or storage deficiencies were identified. The system performance evaluation identified fire flow deficiencies. Fire flow and storage deficiencies were sized based on future conditions (discussed in Section ES 5.4.1) to ensure that improvements were adequately sized to meet existing and future customer needs.

The system capacity analysis also identified the dependency on the Burgess PRV station. Since 2011, the Burgess PRV station has supplied between 59 to 95 percent of the total Lower Zone Demand. To more equally balance the supply contributions between the three Lower Zone regulating stations and to reduce the dependence of the Burgess PRV station, a Residential/Commercial Pressure Regulator Program is recommended. The program will retrofit customer services in the Lower Zone with individual PRVs, so that settings at the Chilco and Madera PRV stations can be adjusted to more closely match the Burgess PRV station without activating customer relief valves that would cause flooding.

ES.5.3.2 Seismic Vulnerability Assessment

A seismic vulnerability assessment was performed to assess MPMW's ability to withstand a major seismic event, such as a magnitude 7.9 earthquake on the San Andreas Fault. The scope of the analysis included meeting with MPMW, reviewing relevant documents, conducting visual assessments of key water system facilities, and preparing a pipeline vulnerability assessment, and documenting findings of the analysis.

The Upper Zone is, for the most part, on competent (non-liquefiable) soils, but because of its proximity to the San Andreas Fault, can expect very strong ground motions in a San Andreas earthquake. The Lower Zone and High Pressure Zone are in areas mapped as having moderate to high liquefaction susceptibility. The pipeline vulnerability assessment found that most risk is in the Lower Zone and High Pressure Zone. During a San Andreas magnitude 7.9 earthquake, 97 pipeline failures (22 leaks, 75 breaks) are estimated to occur. To mitigate potential damage, it is recommended that MPMW place a high priority on replacement of approximately 50,000 feet of pipeline with seismic resistant pipe.

The initial focus for pipeline replacement should be on cast iron pipe (CIP), asbestos cement (AC), polyvinyl chloride (PVC) and unknown pipeline materials in high liquefaction zone areas. For larger-diameter pipelines that are more critical, recommended pipeline material and construction methods include steel with butt-welded joints, ductile iron pipe (DIP) with earthquake resistant joints, molecularly oriented PVC pipe (PVCO) with seismic retrained joints, and high-density polyethylene (HPDE) pipe. Of these materials, steel and DIP are only considered in soils with low corrosivity. For smaller-diameter, less critical pipelines, recommendations include steel pipe with lap or butt-welded joints, DIP with mechanically restrained joints, and PVCO pipe with double-depth bells.

Several other seismic improvements are also recommended, including updating the City's Emergency Response Plan to address earthquake recovery more comprehensively, developing a design procedures manual to incorporate seismic design standards, preparing geotechnical and structural assessments for the Sand Hill Reservoirs, implementing a non-structural anchorage program, and conducting a seismic evaluation of the Maintenance Building.

ES.5.3.3 Pipeline Condition Assessment

The WSMP includes a pipeline condition assessment that was performed to develop a long-term pipeline rehabilitation/replacement plan. The analysis included a risk assessment to prioritize pipelines with the highest risk of failure for replacement. The analysis evaluates the likelihood and consequence of a pipeline failure, to assign risk levels for pipelines within the water system.

The likelihood of failure analysis assesses the probability that a failure will occur, and considers such risk factors as pipeline age, break history, seismic ground shaking, potential for exterior corrosion due to corrosive soils, and areas with higher working pressures that would be more susceptible to leaks and breaks. The consequence of failure considers the potential impacts from a pipeline break, evaluating factors including reduced level of service, traffic impacts, fiscal impacts and environmental impacts, such as discharge of chlorinated water to waterways. Pipeline diameter was used as a proxy for the consequence factors. A summary of the risk assessment ratings is shown in Table ES-3, showing total length of pipelines in each risk level category by zone, and also for the Bayfront Area specifically. Lengths of pipeline shown for the Bayfront Area are included in totals for the Lower Zone and High Pressure Zone.

Table ES-3. Summary of Risk Assessment Results

	Pipeline Length, LF				
Risk Level	Lower Zone	High Pressure Zone	Upper Zone	Total	Bayfront Area[a]
Low	47,720	35	11,961	59,716	2,115
Medium-Low	56,828	1,333	17,783	75,944	6,098
Medium	50,156	4,276	21,369	75,801	22,250
Medium-High	17,193	2,503	14,392	34,087	8,208
High	12,247	16,113	16,196	44,556	18,097
Total	**184,144**	**24,260**	**81,701**	**290,105**	**56,768**

[a] Includes pipes that are located outside of the Bayfront boundary but are critical for supplying the Bayfront area.

To address the medium-high and high categories within the WSMP timeframe (through 2040), West Yost recommends funding replacements at $1.2 million/year in current dollars. Based on recent pipeline construction costs, this would fund approximately 80,000 feet of pipeline replacement within this timeframe. This annual rate of funding is approximately double the current rate of funding for this program.

ES.5.3.4 Advanced Metering Infrastructure Evaluation

MPMW is considering changing its water meter system from manual meter readers by a private company to an AMR or AMI system. As part of the WSMP, MPMW requested that West Yost summarize and evaluate AMR and AMI options.

Implementation of an AMR or AMI system will decrease the time for meter data collection and improve the efficiency of billing operations. Both technologies provide the opportunity for increased customer service through more accurate meter reads. AMI also provides utilities with the opportunity to identify water usage trends in ways that are not achievable with monthly or bi-monthly meter readings. Using near real-time data to remotely monitor and manage the water utility infrastructure, utilities with AMI can proactively alert customers of potential leaks or high water usage.

Implementation of AMI or AMR could be completed as a single program or could be phased in over time. For example, the City of Redwood City started implementation of an AMI program starting in 2008 but is phasing it in over time so that meters won't require end-of-life replacement at the same time and in-house staff can be used to convert meters to AMI. As of early 2017, about 60 percent of Redwood City's system was on AMI.

A conceptual-level cost estimate for the installation of AMR or AMI found that the capital costs were not significantly different, with an estimated cost of $2.37M for AMR compared with an estimated cost of $2.51M for AMI. The annual costs for the AMI analytical software are higher than the AMR software support ($23,800 per year difference). Of these costs, 25 percent of the cost is for new meters, many of which are older meters that MPMW should replace even if an AMI or AMR program is not implemented. Another 25 percent of the cost is labor for contractor installation of meters and associated equipment, which could be offset by using MPMW staff to install meters in a phased program, similar to Redwood City's.

ES.5.3.5 Other System Improvements

Over the course of the WSMP study, other improvements were identified, either by MPMW, or as part of the different WSMP evaluations. These projects have been included in the WSMP to improve system reliability and operational efficiency, and include: new emergency interconnections with Cal Water and City of Palo Alto; a residential and commercial regulator program, to provide more operational flexibility in the Lower Zone; pressure monitoring at SFPUC turnouts, to improve system monitoring; continuation of MPMW's current private backflow inspection program, to minimize potential for cross-connections; and, incorporating seismic design standards into standard details and design guidelines, construction of metered connections with East Palo Alto, development of a Lead Service Replacement program, and development of an Asset Management program.

ES.5.4 Future Water System Evaluation (Chapter 8)

West Yost evaluated the City's water system for future demand conditions to identify deficiencies and recommended improvements. The evaluation included system capacity and performance evaluations, including normal operations, fire flow conditions, water quality operations and emergency operations. Key findings of the future system analysis are summarized below.

ES.5.4.1 System Capacity Analysis

An additional 2.5 MG of storage in the Lower Zone is needed in the future for operational and fire flow purposes, to reduce MPMW's reliance on the SFPUC system for providing peaking capacity.

Approximately 360 feet of 8-inch, 1,210 feet of 10-inch and 5,920 feet of 12-inch diameter pipeline improvements are recommended to improve fire flows in the Lower Zone. Improvements are primarily to reinforce areas that currently have higher fire flow requirements for non-residential uses, and single feeds to the area. These improvements can be implemented as part of MPMW's pipeline renewal and replacement program.

ES.5.4.2 Water Age Evaluation

A water age analysis was performed using the hydraulic model to generally assess water quality. Higher water age is generally indicative of potential water quality problems, such as low chlorine residual. The hydraulic model uses pipeline velocities, storage tank fill and draw rates, and storage tank volumes to calculate water ages in the distribution system. The water age analysis was conducted for future average day demand conditions.

Water ages are generally low – less than 24 hours from point of entry to the system in the Lower and High Zones, which have no storage and three to four days, in the Upper Zone, where the Sand Hill Reservoirs are located.

For the Lower Zone, there is a 2.5-mile long 12-inch diameter pipeline that serves the Dumbarton Pier (fire hydrant for the pier) and a PG&E electrical substation north of Highway 84. The analysis showed that due to the very limited demand in this pipeline, water age is excessive. MPMW confirmed that it is difficult to maintain residual in the pipeline, and West Yost recommends that the pipeline be designated as a non-potable water fire-service pipeline, with a State-approved backflow prevention assembly. MPMW will also need to amend its water permit to reflect this change, and provide signage about non-potable water being used at service locations along the pipeline.

In the Upper Zone, West Yost found that MPMW's current operational practice of operating reservoirs at lower levels during the winter months, when demands are low, helps to maintain water quality. MPMW is also planning to install mixers in the reservoirs.

For dead end pipelines with very low demands, West Yost also recommends installation of automated valves at select blow off locations where MPMW has problems maintaining chlorine residual.

ES.5.4.3 Emergency Operations

Emergency operations were evaluated for each zone, assuming loss of SFPUC supply, and for the Upper Zone, loss of the reservoirs. For the Lower Zone and High Pressure Zone, a hydraulic analysis was performed to evaluate meeting system demands from emergency wells being constructed in the Emergency Water Supply Program. For the Upper Zone, calculations were prepared to evaluate duration of service under future average day demand conditions with the existing storage reservoirs available.

For the Lower Zone and High Pressure Zone analysis, all SFPUC turnouts were assumed to be out of service, with demands met from the planned emergency wells. The analysis found that the planned wells can reliably supply the lower zone at adequate pressure, as long as demands are less than 3,000 gpm. West Yost recommends the installation of check valve bypasses at three locations where there are normally closed valves, to be able to provide emergency service to the High Zone and to SRI, which is supplied directly from the Burgess turnout.

In the Upper Zone, Sand Hill reservoirs are operated between 8 to 12 feet during winter months. Under projected future average day demands, supply would last for approximately 32 hours, if the reservoirs were at 8 feet. When Sand Hill reservoirs are out of service, the zone can be supplied by the Sharon Heights Pump Station. Installation of a variable frequency drive is recommended to allow operation of a pump on system pressure, when the reservoirs are out of service.

In addition, MPMW is proceeding with the Emergency Supply Program, to install wells to serve the Lower Zone during an emergency. The first well will be completed by the end of 2018, and one or two additional wells are planned, to provide a total supply of 3,000 gallons per minute (gpm). The 3,000 gpm goal was recommended by City staff as the approximate flow needed to meet the average day demand of 1,600 gpm plus the reduced fire flow of 1,500 gpm. This program will provide emergency supply benefits to the Lower and High Pressure Zone.

ES.6 CAPITAL IMPROVEMENT PROGRAM (CHAPTER 9)

The total capital cost of water system improvements to support MPMW's water distribution system is approximately $90 million (M). Improvements are summarized on Figure ES-3A and ES-3B and on Table ES-4.

Because of the magnitude of the capital improvement program (CIP), projects have been prioritized into very high, high and medium priority, which can be used to evaluate implementation timing of projects based on affordability to MPMW. Priorities were assigned based on perceived risk of not implementing particular projects.

Very high priority projects are those that improve system resiliency, address aging facilities, and improve MPMW's earthquake planning and response. These projects total $53M of the overall CIP. High priority projects are those that are also important to improve system resiliency, provide more system operational reliability and flexibility, and address aging equipment. These projects total $16M. Medium priority projects are those projects which have lower priority because there are other higher priority projects that also help to support the same goals, and/or because the consequence of not implementing projects has less risk. These projects total $20M.

Table ES-4. Recommended Water Distribution System Capital Improvement Program[a]

CIP ID	Zone	Improvement Type	Reason for Improvement	Improvement Description	Location	Priority	Estimated Construction Cost[b]	Capital Cost (includes mark-ups)[c]
Capacity Improvements								
Fire Flow Improvements								
CAP-01	High Pressure	Fire Flow	Improvements listed in this section are needed to address fire flow deficiencies identified in the hydraulic analysis	2,030 feet of new 12-inch pipe	Along Haven Avenue west of 3585 Haven Avenue	High	$975,000	$1,268,000
CAP-02	High Pressure	Fire Flow		740 feet of replace 12-inch pipe	Along Chilco Street between Constitution Drive and Chilco Street	High	$354,000	$460,000
CAP-03	Lower	Fire Flow		600 feet of new 12-inch pipe	Along private easements between O'Brien Drive and alley south of O'Brien Drive west of 1330 Obrien Drive; Along private easements between O'Brien Drive and alley south of O'Brien Drive west of 1460 Obrien Drive	High	$285,000	$371,000
CAP-04	Lower	Fire Flow		2,110 feet of replace 12-inch pipe	Along O'Brien Drive between Willow Road and Kelly Court; Along private easement east of Willow Road and north of Ivy Drive	High	$1,014,000	$1,318,000
CAP-05	Lower	Fire Flow		360 feet of replace 8-inch pipe, 440 feet of replace 10-inch pipe, 440 feet of replace 12-inch pipe	Along Laurel Street West of Burgess PRV Station; along private easement west of Burgess PRV Station	High	$508,000	$660,000
CAP-06	Lower	Fire Flow		770 feet of replace 10-inch pipe	Within Corporate Yard	High	$318,000	$413,000
						Subtotal	$3,454,000	$4,490,000
Storage Improvements								
CAP-07	Lower	Storage	Tank and booster pump station improvements are recommended to meet operational, emergency, and fire flow storage needs of the Lower and High Pressure Zone	2.5 MG Storage Tank (partially buried)[d]	TBD[f]	Medium	$10,948,000	$14,233,000
CAP-08	Lower	Storage		7.5 mgd (firm capacity) booster pump station and associated on-site back up generator for storage tank[e]		Medium	$3,272,000	$4,253,000
						Subtotal	$14,220,000	$18,486,000
						Total Capacity Improvements	**$17,674,000**	**$22,976,000**
Reliability Improvements								
REL-01	Upper	Reliability Improvement	Mitigate seismic and geotechnical hazards. Specific project dependent on findings of Project REL-07	Upgrade/replace wood roofs on Sand Hill Reservoirs and mitigate geotechnical concerns. Value is a placeholder budget and should be revised with the findings from MISC-03[g]	Sand Hill Reservoirs	High	$3,900,000	$5,070,000
REL-02	Lower, High Pressure, Upper	Reliability Improvement	Mitigate seismic hazard.	Implement a non-structural anchorage program as part of the regular maintenance budget	System-Wide	Very High	$20,000	$26,000
REL-03	Lower	Reliability Improvement	Improves emergency supply reliability	New metered interconnection with Cal Water at the Alma Street Crossing. Project assumes an estimated 2,000 LF of 12-inch pipeline, with a portion within a new pedestrian bridge, and meter within a vault.	At the intersection of El Camino Real and Middle Avenue	Very High	$1,112,000	$1,500,000
REL-04	Lower	Reliability Improvement	Improves emergency supply reliability	New metered interconnection with City of Palo Alto at the Pope Chaucer Bridge (San Francisquito Creek). Project assumes an estimated 250 LF of new 12-inch pipeline, all assumed to be within a new bridge, and a meter within a vault	Along Chaucer Street, between Woodland and Palo Alto Avenues.	Very High	$228,000	$297,000

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Table ES-4. Recommended Water Distribution System Capital Improvement Program[a]

CIP ID	Zone	Improvement Type	Reason for Improvement	Improvement Description	Location	Priority	Estimated Construction Cost[b]	Capital Cost (includes mark-ups)[c]
REL-05	Lower	Reliability Improvement	Allows more use of Chilco and Madera PRV stations, with less reliance on Burgess PRV station.	Implement a residential/commercial pressure regulator program in the lower zone to help keep customer service pressures from exceeding 80 psi, allowing Chilco and Madera pressure regulating station settings to be set equal to the Burgess PRV station[h]	Various	High	$1,872,000	$2,434,000
REL-06	Lower Zone	Reliability Improvement	Cannot maintain water quality in large-diameter pipeline	Conversion of Dumbarton pipeline (12-inch) into a non-potable pipeline	Dumbarton Bridge	High	$100,000	$130,000
REL-07	Lower, High Pressure, Upper	Reliability Improvement	Improve water quality	Installation of automated blowoffs at dead-end locations	System-Wide	High	$150,000	$195,000
REL-08	Upper	Reliability Improvement	Improve water quality	Reservoir Mixers at Sand Hill Reservoirs to avoid reservoir stratification and improve water quality	Sand Hill Reservoirs	Very High	$120,000	$156,000
REL-09	Lower	Reliability Improvement	Planned as part of the Supplemental Emergency Water Supply Project to provide emergency supply to Lower Zone.	New well with a design flow of 1,500 gpm and dynamic head of 265 feet, 100 feet of 12-inch pipe	TBD[i]	Very High	$3,295,000	$4,284,000
REL-10	Lower	Reliability Improvement	Planned as part of the Supplemental Emergency Water Supply Project, only if two wells cannot supply program objective of 3,000 gpm	New Well required if REL-01 is unable to meet a design production of 1,500 gpm.	TBD[i]	Very High	$3,295,000	$4,284,000
REL-11	Lower	Reliability Improvement	SRI is served directly from the SFPUC Burgess turnout without pressure regulation. Replacing the existing normally closed valve with a check valve would interconnects Lower Zone to SRI if the SFPUC Burgess turnout is out of service. Under normal conditions, the check valve would prevent unregulated high pressure water from flowing into the Lower Zone.	One 10-inch check valve, required to be able to provide supply from the Lower Zone to SRI In the event that the Burgess SFPUC turnout is out of service. Check valve assumed to be installed near the existing normally closed valve between the 10-inch bypass and the Burgess PRV station.	At Burgess PRV Station	Very High	$65,000	$85,000
REL-12	High Pressure	Reliability Improvement	The High Pressure Zone is served directly from the SFPUC Hill Turnout. Replacing the existing normally closed valves with check valves would Interconnect the Lower Zone and High Pressure Zone if the Hill turnout is out of service. Under normal conditions, the check valve would prevent unregulated hugh pressure water from flowing into the Lower Zone.	Two 12-inch check valve, required to be able to provide supply from the Lower Zone if the Hill SFPUC turnout is out of service. Both check valves are assumed to be installed at existing normally closed valve locations.	One at intersection of Del Norte Avenue and Terminal Avenue; One at intersection of Del Norte Avenue and Market Place	Very High	$130,000	$169,000
REL-13	Upper	Reliability Improvement	Improves pressure management in Upper Zone during outage of Sand Hill Reservoirs.	Equip Sharon Heights Pump Station with VFD's to improve pressure management in Upper Zone	Sharon Heights Pump Station	Medium	$195,000	$254,000
						Total Reliability Improvements	**$14,482,000**	**$18,884,000**

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Table ES-4. Recommended Water Distribution System Capital Improvement Program[a]

CIP ID	Zone	Improvement Type	Reason for Improvement	Improvement Description	Location	Priority	Estimated Construction Cost[b]	Capital Cost (includes mark-ups)[c]
Rehabilitation and Replacement Improvements								
RR-01	Lower, High Pressure, Upper	Program	Needed to maintain and improve the system. Pipelines identified in the Seismic Vulnerability Assessment are targeted as highest priority. As part of this program, MPMW should also identify opportunities to re-locate pipelines on private property to current rights-of-way	Pipeline replacement program, budgeted at $1.6M/year (Constructions cost with contingencies in current dollars, or $2.0M/yr in capital costs in current dollars) from 2018 through 2040. Capacity projects to improve fire flow shown above ($3.45M) are budgeted separately, but assumed to be part of this program. Therefore, remaining overall cost equals: [$1.6M/year x 23 years] - $3.45M	System-Wide, with focus on pipelines identified in Seismic Vulnerability Assessment and Capacity Evaluation as Highest Priority	Very High	$32,426,000	$42,150,000
						Total Rehabilitation and Replacement Improvements	**$32,426,000**	**$42,150,000**
Other System Improvements and Studies								
MISC-01	Lower, High Pressure, Upper	Other	Refines information for pipeline replacements to address seismic hazards.	Conduct pipeline hazard assessment (including field survey of geologic conditions along critical pipeline segments, review of boreholes, update liquefaction and landslide models)[g]	System-Wide	Medium	$50,000	$65,000
MISC-02	Lower, High Pressure, Upper	Other	Refine information for pipeline replacements to address seismic hazards.	Update Pipeline analysis based on updated hazard assessment[g]	System-Wide	Medium	$20,000	$26,000
MISC-03	Upper	Other	Addresses current codes which are more stringent than codes in place when structures were designed.	Conduct a structural, geotechnical, and seismic evaluation of Sand Hill Reservoir site[g]	Sand Hill Reservoirs	Very High	$60,000	$78,000
MISC-04	--	Other	Assess condition and identify retrofit needs to mitigate seismic hazards.	Conduct evaluation of Maintenance Building[g]	Burgess Drive	Medium	$20,000	$26,000
MISC-05	Lower, High Pressure, Upper	Other	Provide plan for operational response and recovery following earthquake	Develop post earthquake operational and recovery plan[g]	System-Wide	Very High	$40,000	$52,000
MISC-06	Lower, High Pressure, Upper	Other	Specific recommendations to be developed in operational and recovery plans.	Develop a plan and acquire equipment for re-fueling generators following an earthquake	System-Wide	Very High	$50,000	$65,000
MISC-07	--	Other	MPMW is currently developing standard details and design guidelines. This project should incorporate seismic design procedures or reference ASCE manual of practice for seismic design of water and sewer pipelines.	Develop Standard Details and Design Guidelines	System-Wide	Very High	$50,000	$65,000
MISC-08	Lower, High Pressure, Upper	Other	Replace aging meters, facilitate data collection and monitoring, reduce water loss.	Meter Replacement/Enhancement Program (assumes full system upgrade to AMI)[k]	System-Wide	High	$3,475,183	$4,518,000
MISC-09	Lower and High Pressure	Other	Improve system monitoring	Install pressure monitors and connect all turnouts to SCADA System	At Burgess, Chilco, Madera and Hill turnouts	Medium	$780,000	$1,014,000
MISC-10	Lower, High Pressure, Upper	Other	Protects system from cross-contamination.	Continued Implementation of the Backflow Prevention Program	System-Wide	Underway	--	--
MISC-11	--	Other	Increase sustainability of potable water supply.	Conduct further recycled water studies for continued development of this program	System-Wide	Medium	$150,000	$195,000
MISC-12	Lower	Other	Provides MPMW with a means for metering water that may need to be supplied to East Palo Alto in the event of an emergency.	Construct metered connections and replace valves at interties with East Palo Alto	University Avenue, O'Brien Drive and Willow Road	Medium	Cost to be Determined	

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Table ES-4. Recommended Water Distribution System Capital Improvement Program[a]

CIP ID	Zone	Improvement Type	Reason for Improvement	Improvement Description	Location	Priority	Estimated Construction Cost[b]	Capital Cost (includes mark-ups)[c]
MISC-13	Lower, High Pressure, Upper	Program	State requirement to eliminate piping and fittings in water service connections that contain lead, if found in the distribution system.	Development of a Lead Service Replacement Program	System-Wide	Very High	Cost to be Determined	
MISC-14	Lower, High Pressure, Upper	Other	Provides MPMW with a roadmap for future capital expenditures in an effort uphold customer service by making targeted improvements to assets that are most critical in function or condition.	Development of an Asset Management Program	System-Wide	Medium	$150,000	$195,000
						Total Other System Improvements	**$4,845,183**	**$6,299,000**
						TOTAL CAPITAL IMPROVEMENT PROGRAM	**$69,427,183**	**$90,309,000**
						Very High Priority	**$40,891,000**	**$53,211,000**
						High Priority	**$12,951,183**	**$16,837,000**
						Medium Priority	**$15,585,000**	**$20,261,000**
						Total	**$69,427,183**	**$90,309,000**

(a) Costs shown are based on the August 2017 San Francisco ENR CCI of 12,037 and are rounded to nearest $1,000.

(b) Costs include mark-ups equal to 30 percent (Base Construction Costs plus Construction Contingency).

(c) Costs include mark-ups equal to 69 percent (Base Construction Costs plus Construction Contingency: 30 percent and; Professional Services: 30 percent of Base Construction Cost plus Contingency).

(d) Costs for the proposed tank include a land purchase/lease cost (to be purchased from the City) totaling $4.6M, which is based on the land lease price of the existing emergency well ($105/sq. ft.) site and assumes a one-acre site is required.

(e) Booster pump station capacity was assumed to be 7.5 mgd, capable of draining a 2.5 mgd tank in 8 hours.

(f) Storage Tank and Booster Pump station location unknown. Additional siting evaluations are recommended to confirm size and locations of proposed future storage.

(g) Costs directly from Vulnerability Assessment and do not include additional contingency. However, Capital Costs mark-ups are equal to 30 percent to budget staff time to implement improvement.

(h) Assumes 1,800 meter connection retrofits at $800 each.

(i) From Vulnerability Assessment.

(j) For the purposes of the hydraulic evaluation, the new well location was assumed to be near the intersection of Willow Road and Coleman Avenue. However, actual location is unknown, and groundwater well siting analyses and testing are required to determine the location and production capacity (which may result in two wells being needed).

(k) Costs directly from Advanced Meter Infrastructure Evaluation TM (West Yost, October 2017) and includes the software cost of $25,000 per year through buildout (i.e., through 2040 or 23 years), shown in current dollars (i.e. 23 years x $25,000/yr).

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Table ES-5 summarizes the planning-level capital cost estimates by improvement priority.

Table ES-5. Summary of Capital Improvement Program Capital Costs by Priority and Improvement Type[a]

Improvement Type	Priority			
	Very High	High	Medium	Total
Capacity	$0.00	$4.49	$18.49	**$22.98**
Reliability	$10.80	$7.83	$0.25	**$18.88**
Rehabilitation and Replacement	$42.15	$0.00	$0.00	**$42.15**
Other	$0.26	$4.52	$1.52	**$6.30**
Total	**$53.21**	**$16.84**	**$20.26**	**$90.31**

(a) Capital costs are presented in million dollars.

ES.7 OPERATIONS AND MAINTENANCE EVALUATION (CHAPTER 10)

West Yost performed a staffing assessment and maintenance review, completed in early 2016.

The staffing assessment reviewed current positions and duties of staff, and compared staffing levels with similar sized municipal utilities. The analysis found that current O&M staff levels do not allow for recommended preventative maintenance or operational optimization tasks to be performed, and that staffing levels are insufficient when compared to the O&M staffing levels of similar size utilities.

West Yost performed a maintenance review to assess current maintenance procedures for different water system assets. MPMW O&M staff perform day-to-day corrective maintenance, and some preventative maintenance tasks, but there are many preventative maintenance tasks that are not occurring at the frequency that is recommended by industry best practices, such as valve exercising, hydrant inspection and testing, pressure reducing valve (PRV) maintenance, and reservoir maintenance. Maintenance work orders are currently tracked using excel spreadsheets as there is no formal computerized maintenance and management system. Maintenance documentation is becoming backlogged due to time-constraints and lack of clerical support for field operations staff.

West Yost reviewed operational practices related to monitoring, water quality, water efficiency and emergency planning. Operations are being monitored through physical inspections and remotely through supervisory control and data acquisition (SCADA) telemetry. Water quality is good and sampling is being performed in compliance with regulatory requirements. Water system losses are being tracked and a meter replacement program has begun to address unaccounted for water loss. The MPMW Emergency Response Plan (ERP) is out of date and necessary exercises associated with emergency planning are not occurring.

West Yost recommends seven full-time staff based on results of several staffing assessment analyses which include current O&M duties, recommended preventative maintenance and operational optimization tasks, and the results of a comparison with similar size utilities. Table ES-6 provides a summary of the findings, conclusions of various assessments, and overall recommendations associated with each of the reviews and assessments.

Table ES-6. Summary of Key Systems Operations and Maintenance Findings and Recommendations

Category	Recommendation
Maintenance Review Summary • Prepare SOP's to provide step by step instructions to help workers carry out routine operations activities • No formal condition assessments have been conducted on system pipes, valves, meters, or hydrants • Maintenance work order logs are being prepared in excel spreadsheets and date back to 2014 • O&M staff have replaced and repaired many fire hydrants over the past two years • O&M staff are inspecting and testing fire hydrants, but not all hydrants are being inspected and/or tested annually • PRV's are inspected daily and the Burgess and Madera PRV's are tested biannually • Valving configurations at the PRV stations do not allow for easy repair and the stations would be difficult to take out of service • Connecting pipelines to the Burgess PRV are located under existing buildings • Valves are being exercised at a frequency of once every four years • Air release valve locations are unknown and maintenance is not being performed on these valves • The booster pump station is inspected daily and monitored via SCADA • The reservoirs are currently visually inspected daily. Water quality sampling at the reservoirs is conducted on a weekly basis. • The reservoirs do not have mixers installed to provide consistent water quality. A written protocol is in place for improving water quality in the reservoirs. • An interior reservoir inspection by divers was scheduled for January 2016 to evaluate the interior of the tanks • Dead-end mains are being flushed and monitored weekly for water quality • MPMW is currently in the process of updating its standard drawings	
Condition Assessment of Pipes, Valves, Meters, and Hydrants	• Include additional details in maintenance logs regarding conditions for future reference and input in to GIS database • Start condition assessment on infrastructure based on age and size
Hydrant Repair, Replacement, and Testing	• Implement routine inspection and maintenance from for hydrants • Perform biennial or triennial hydrant testing • Continue to keep records on fire hydrant maintenance, inspections, and testing • Prepare written guideline for hydrant inspection and testing procedures
PRV Maintenance	• Test PRV's annually, and rebuild and paint every 5 years • Test Madera PRV and rebuild, test Chilco PRV annually • Relocate Burgess PRV to eliminate piping that runs under existing structures • Without pressure regulation on the customer side, MPMW has little flexibility and has to rely on the Burgess PRV to serve most of the Lower Zone
Valve Maintenance	• Exercise Valves (12-inch and larger) every one to three years • Exercise valves (smaller than 12-inch) every four years • Locate ARV's and inspected annually • Document valve exercising info
Booster Pump Station Maintenance	• Perform daily inspections • Follow O&M and manufacturers recommendation for Pump Station maintenance • Test and service generator on a monthly basis • Measure pump capacity and efficiency with pump tests • Monitor for heat, vibration, and noise long-term • Document maintenance for reference and equipment warranty conditions • Prepare a site specific O & M Manual for the reconstructed Sharon Heights Booster Pump Station and keep it onsite as a reference for required maintenance activities
Reservoir Maintenance	• Perform daily inspections • Inspect reservoir interior every three to five years. • Clean reservoir on an annual or bi-annual basis • Recoat interior and roof of reservoir on a five to seven frequency or as needed • Inspect roof after storm events for ponding • Maintain and monitor vegetation around reservoirs • Prepare written operations manual for reservoir draining and filling, reservoir isolation, and disinfection
System Flushing	• Flush all dead end mains annually or as required to maintain water quality
Standardization of Parts and Materials	• Update standard drawings and create standard specifications • Prepare design guidelines • Involve O&M staff and preferences in standards and specifications updates • Involve O&M staff in plan reviews • Involve O&M staff in materials submittal reviews and construction inspections • Expose O&M staff to new information and technologies through participation in local, state, and national organizations

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Table ES-6. Summary of Key Systems Operations and Maintenance Findings and Recommendations

Category	Recommendation
Operations Optimization Review Summary • O&M staff visually inspect and use SCADA telemetry to remotely monitor critical system components • Water quality is good and sampling meets regulatory compliance requirements • An on-call operator is assigned during non-work hours to monitor the system and respond to emergency situations • A Computerized Maintenance and Management System (CMMS) is being developed. • Lost and unaccounted for water is being tracked and recorded • Customer meters are being replaced and repaired and remote reading capability is being added to these meters • A meter replacement program is recommended to replace all customer meters after they have reached a certain age Implementation of an AMR or Automated Meter Infrastructure program is being evaluated • Staff keeps records of unplanned discharges • MPMW has a Water System Emergency Response Plan that was prepared in 2009 • MPMW is a member of the California Water/Wastewater Agency Response Network	
General	• Establish Level of Service standards and goals for system performance, energy and water efficiency, and customer service and regularly evaluate performance against them • Maintain accurate system maps and records
Water Quality	• Prepare for revised TCR by documenting data on positive samples • Update sampling plan periodically based on changes that occur to the number of customers • Regularly review changes to sampling requirements through AWWA regulatory updates • Continue current sampling program
Monitoring	• Record and store SCADA data for future reference • Update SCADA to allow multiple users to monitor at the same time • Include preventative maintenance items and manufacturers recommended maintenance items in new CMMS program • Set reachable KPI targets for CMMS and evaluate them monthly
Energy Efficiency	• Record and analyze power charges for BPS • Evaluate operations and possible power savings based on time of use rates • Adding mixing within the reservoirs would change the operating requirements and open up opportunities for long-term energy savings
Water Efficiency	• Regularly calibrate large meters and SFPUC meters • Continue tracking lost and unaccounted for water with goal of achieving less than 10%. • Inaccuracies in existing production and consumption water meters makes assessing water loss difficult • Continue meter and service replacements and track effects on water loss • Continue keeping records of meter replacements and include data in GIS database • Continue implementation of AMR to reduce manual meter re-reads • Determine cost benefit for a leak detection program • Continue keeping records for unplanned discharges and include in GIS database
Emergency Planning	• Update and review Emergency Response Plan annually • Update Vulnerability Assessment, if needed • Conduct annual training tabletop exercises and communications drills • Conduct annual emergency exercises • Coordinate exercises with other local and regional agencies • Review and implement Seismic Vulnerability Assessment improvement program
Staffing Level Assessment Summary	• Existing staff are doing well in keeping up with day to day duties and corrective maintenance tasks • There is a shortage of staff to complete recommended preventative maintenance tasks and document maintenance activities • Work Orders associated with manual meter re-reads, final meter readings, and meter turn-offs represent a drain on operations staff resources • Backlog in documentation is occurring due to lack of office support • Existing staff run the risk of becoming burned-out based on current on-call requirements and lack of back-up staff • Current temporary employees are restricted in their hours and are not certified operators • Comparison to similar size utilities indicates that existing staffing is lacking in full time operator positions
Existing O&M Staff Assessment	• Several maintenance tasks are not being performed or are not being performed based on prudent industry practices due to a lack of sufficient staffing resources • Hire a minimum of six qualified operators to alternate on-call duties so each operator doesn't have to be available more than one week every six weeks • Hire office employee to complete administrative type duties like documentation, inventory management, purchasing, and reporting
Comparison to Similar Size Utilities	• Similar size utilities have an average O&M staffing level of seven full-time field employees not including administrative support.
Staffing Assessment Recommendations	• Provide staffing level of a minimum of six certified operators and one administrative person specifically assigned to provide office assistance for documentation, inventory management, purchasing, and reporting. • Hire operators with both treatment and distribution operator certifications to be able to provide additional help with future well sampling and fill-in for the existing Water Quality Specialist • Hire operator with experience in groundwater well water quality sampling and operations and maintenance. • Additional staffing beyond the recommended seven full-time employees may be needed for anticipated future tasks associated with a proposed new emergency well and implementation of a recycled water program.

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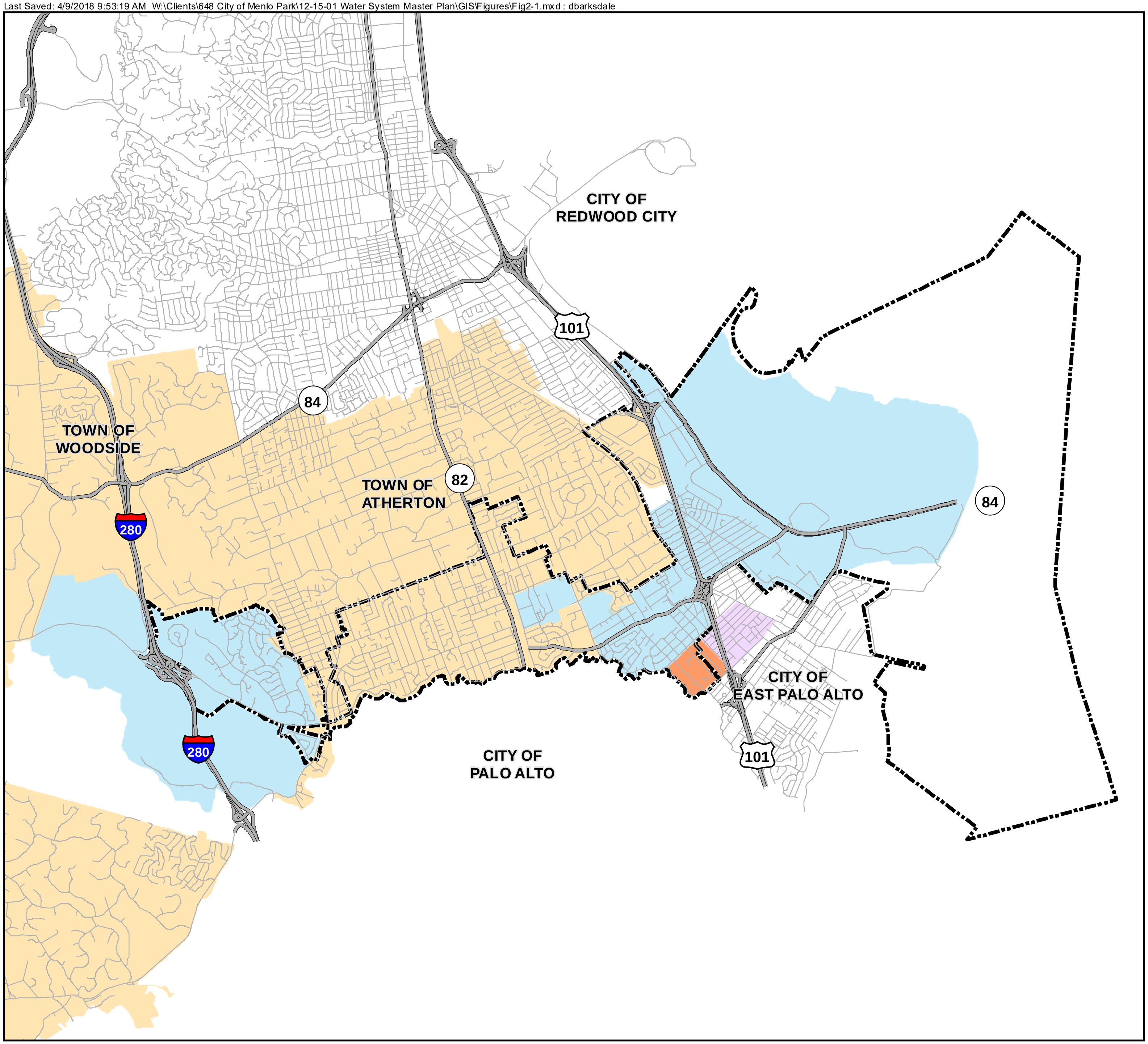

Notes:
1. City limit shapefile downloaded from San Mateo County GIS on 09-15-2015.

Figure ES-1

Overview Map

Menlo Park Municipal Water
Water System Master Plan

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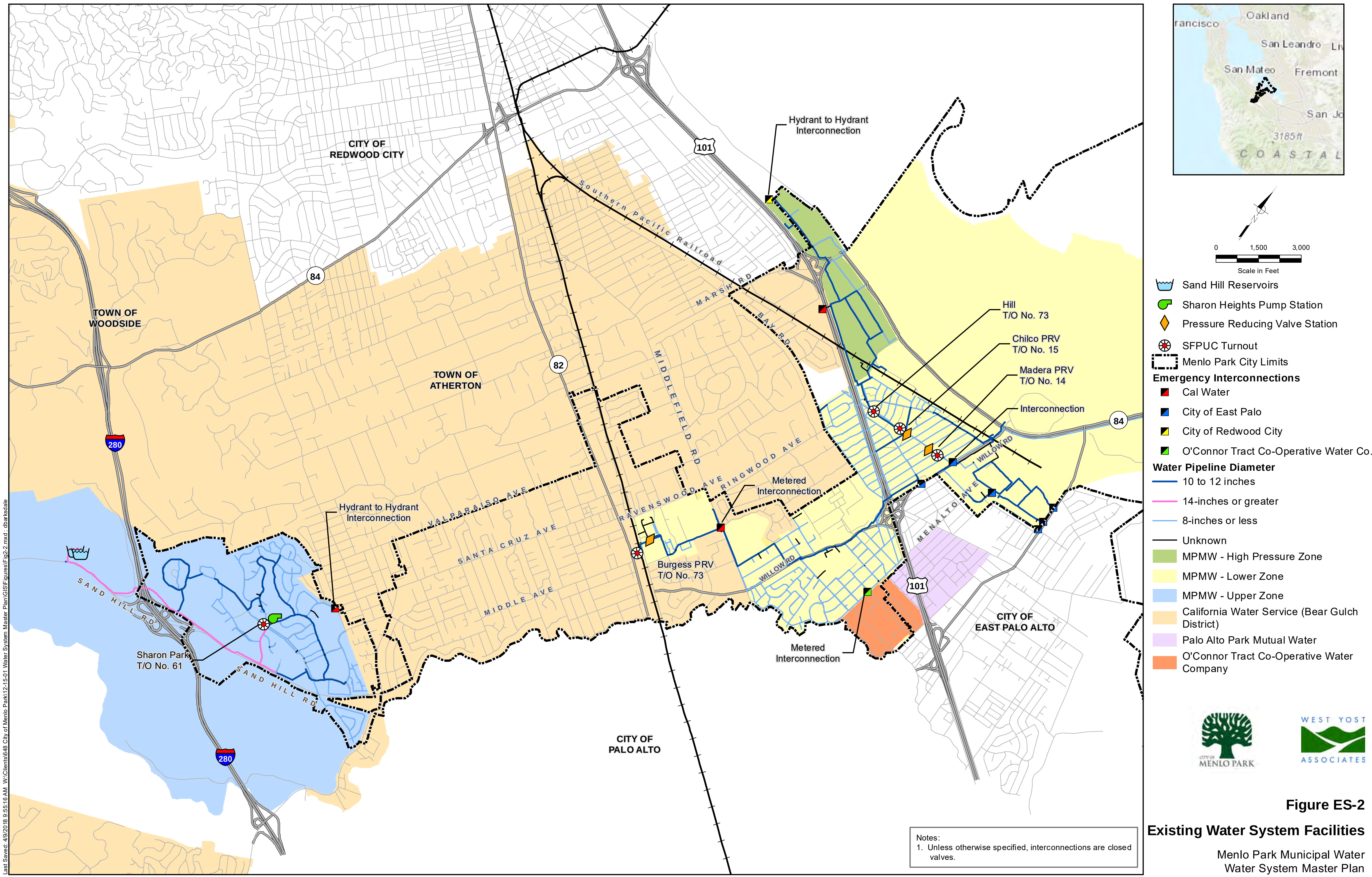

Figure ES-2

Existing Water System Facilities

Menlo Park Municipal Water
Water System Master Plan

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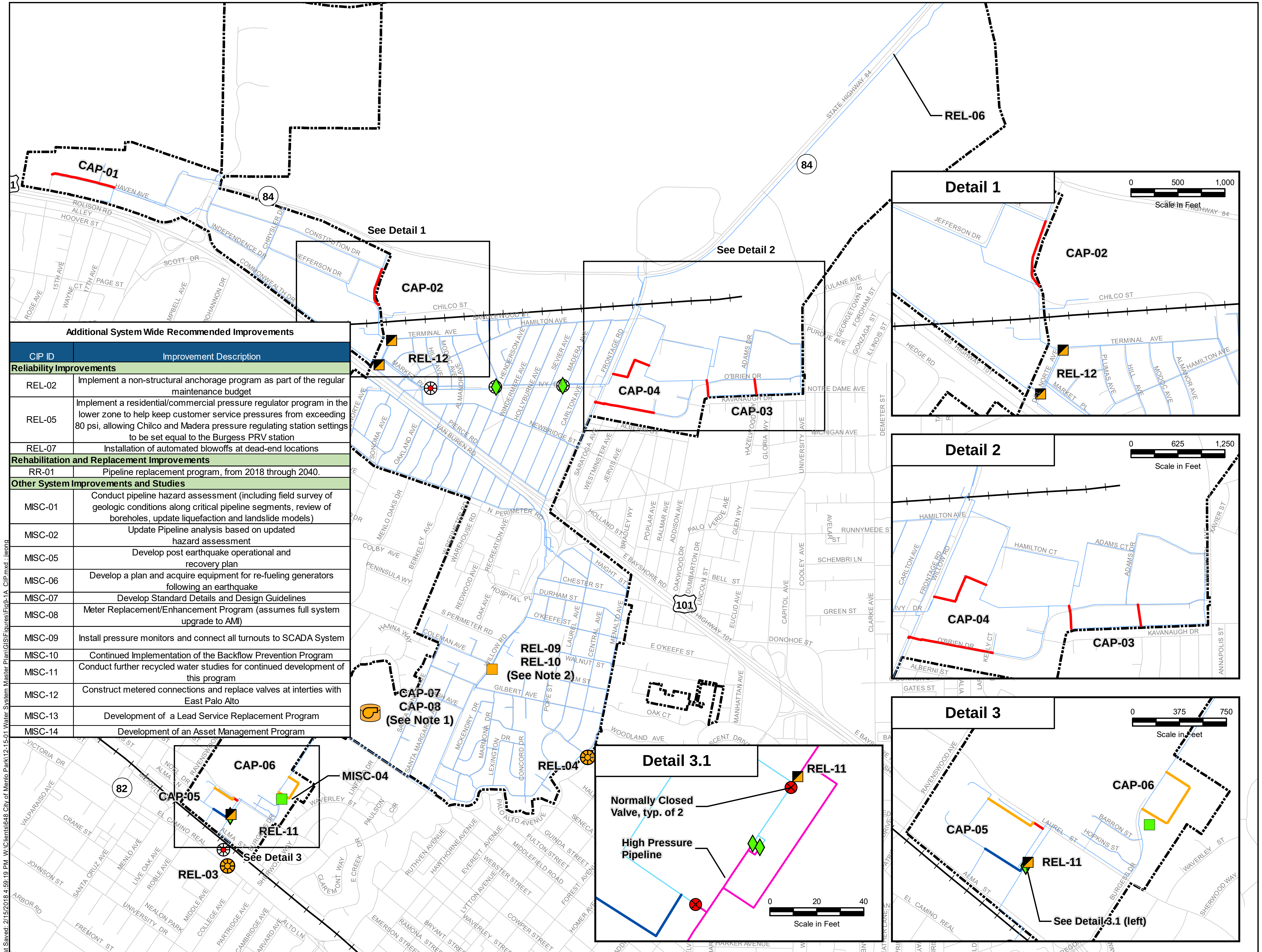
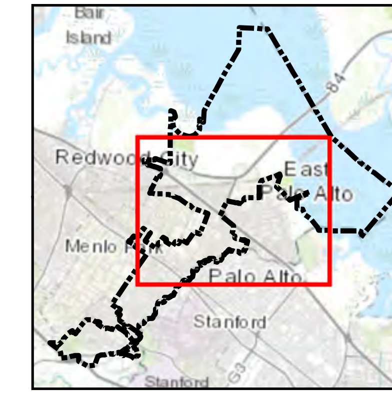


Additional System Wide Recommended Improvements

CIP ID	Improvement Description
Reliability Improvements	
REL-02	Implement a non-structural anchorage program as part of the regular maintenance budget
REL-05	Implement a residential/commercial pressure regulator program in the lower zone to help keep customer service pressures from exceeding 80 psi, allowing Chilco and Madera pressure regulating station settings to be set equal to the Burgess PRV station
REL-07	Installation of automated blowoffs at dead-end locations
Rehabilitation and Replacement Improvements	
RR-01	Pipeline replacement program, from 2018 through 2040.
Other System Improvements and Studies	
MISC-01	Conduct pipeline hazard assessment (including field survey of geologic conditions along critical pipeline segments, review of boreholes, update liquefaction and landslide models)
MISC-02	Update Pipeline analysis based on updated hazard assessment
MISC-05	Develop post earthquake operational and recovery plan
MISC-06	Develop a plan and acquire equipment for re-fueling generators following an earthquake
MISC-07	Develop Standard Details and Design Guidelines
MISC-08	Meter Replacement/Enhancement Program (assumes full system upgrade to AMI)
MISC-09	Install pressure monitors and connect all turnouts to SCADA System
MISC-10	Continued Implementation of the Backflow Prevention Program
MISC-11	Conduct further recycled water studies for continued development of this program
MISC-12	Construct metered connections and replace valves at interties with East Palo Alto
MISC-13	Development of a Lead Service Replacement Program
MISC-14	Development of an Asset Management Program



0 900 1,800
Scale in Feet

- Proposed Pump Station
- Proposed Tank
- Proposed Check Valve
- Proposed Interconnection
- Proposed Emergency Well
- Existing Emergency Well
- Existing Pressure Reducing Valve Station
- SFPUC Turnout
- Proposed 8-inch Pipeline
- Proposed 10-inch Pipeline
- Proposed 12-inch Pipeline
- Existing Pipeline
- Water Service Area

Notes:
1. Storage Tank and Booster Pump station location is unknown and additional siting evaluations are recommended to confirm size and location of proposed future storage. The location shown on this figure is only shown as a place holder.
2. For the purposes of the hydraulic evaluation, the new well location was assumed to be near the intersection of Willow Road and Coleman Avenue. For the analysis it was assumed a full 1,500 gpm of production capacity was achieved. However, the actual location is unknown; and groundwater well siting analyses and testing are required to determine the future locations and production capacity.
3. Refer to Table ES-4 for project descriptions and associated costs.

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Figure ES-3A
Recommended Improvements for the Lower and High Pressure Zones
Menlo Park Municipal Water
Water System Master Plan

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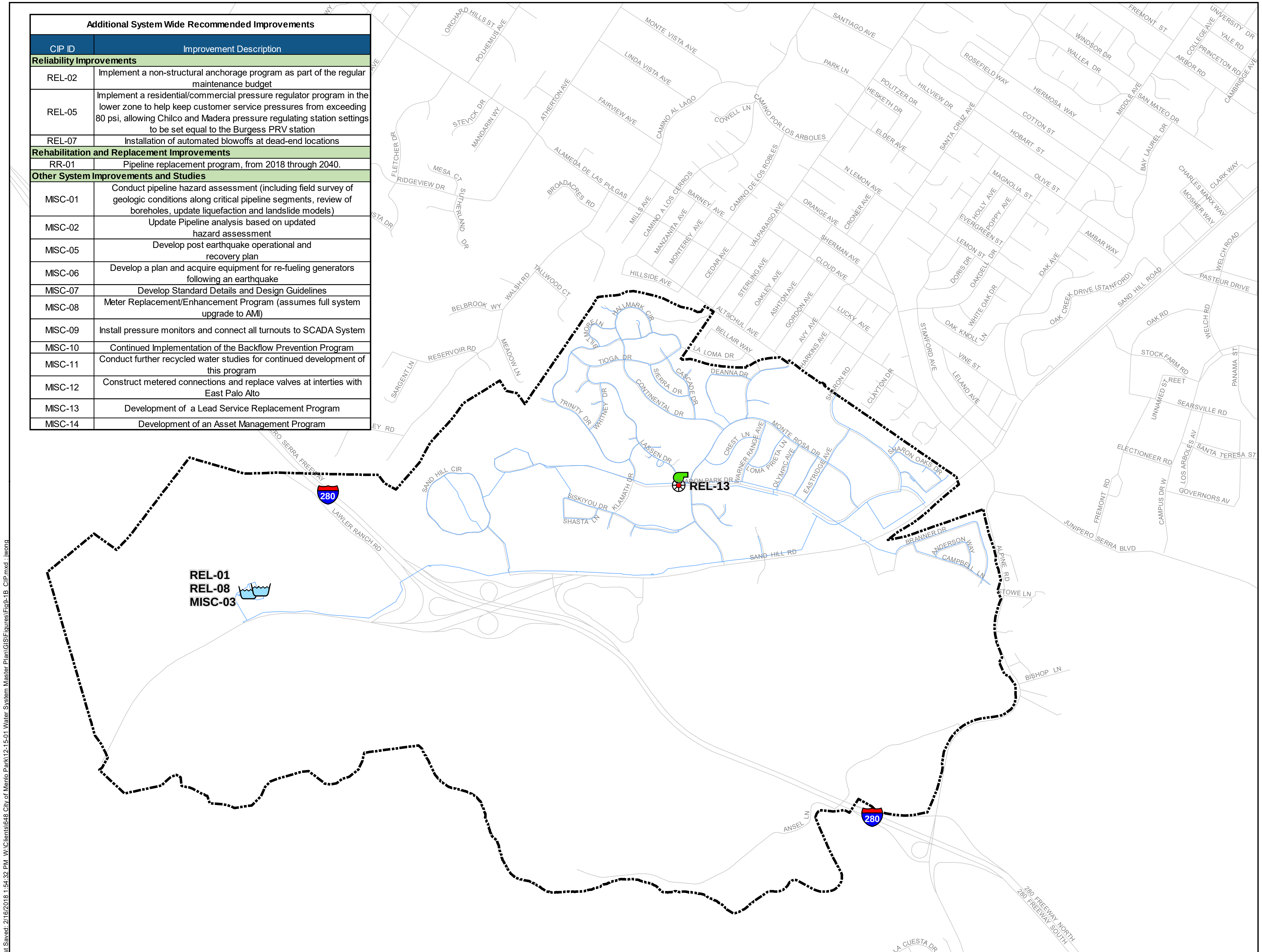
Additional System Wide Recommended Improvements	
CIP ID	Improvement Description
Reliability Improvements	
REL-02	Implement a non-structural anchorage program as part of the regular maintenance budget
REL-05	Implement a residential/commercial pressure regulator program in the lower zone to help keep customer service pressures from exceeding 80 psi, allowing Chilco and Madera pressure regulating station settings to be set equal to the Burgess PRV station
REL-07	Installation of automated blowoffs at dead-end locations
Rehabilitation and Replacement Improvements	
RR-01	Pipeline replacement program, from 2018 through 2040.
Other System Improvements and Studies	
MISC-01	Conduct pipeline hazard assessment (including field survey of geologic conditions along critical pipeline segments, review of boreholes, update liquefaction and landslide models)
MISC-02	Update Pipeline analysis based on updated hazard assessment
MISC-05	Develop post earthquake operational and recovery plan
MISC-06	Develop a plan and acquire equipment for re-fueling generators following an earthquake
MISC-07	Develop Standard Details and Design Guidelines
MISC-08	Meter Replacement/Enhancement Program (assumes full system upgrade to AMI)
MISC-09	Install pressure monitors and connect all turnouts to SCADA System
MISC-10	Continued Implementation of the Backflow Prevention Program
MISC-11	Conduct further recycled water studies for continued development of this program
MISC-12	Construct metered connections and replace valves at interties with East Palo Alto
MISC-13	Development of a Lead Service Replacement Program
MISC-14	Development of an Asset Management Program



Notes:
1. Refer to Table ES-4 for project descriptions and associated costs.

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Figure ES-3B
Recommended Improvements for the Upper Pressure Zone

Menlo Park Municipal Water
Water System Master Plan

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Introduction

1.1 WATER SYSTEM MASTER PLAN PURPOSE

This Water System Master Plan (WSMP) for Menlo Park Municipal Water (MPMW) is a comprehensive evaluation of MPMW's distribution system. The WSMP identifies strategies for cost-effectively meeting MPMW's distribution system infrastructure needs; guides capital expenditures for the system; furnishes important guidance to enhance renewal and replacement strategies and operational and water quality practices; and provides a framework for diversifying MPMW's water supply. To accomplish these goals, the following work tasks were performed in the WSMP:

- Evaluated and summarized existing water system and key system facilities;
- Completed a comprehensive field mapping program to update MPMW's GIS mapping of water system features;
- Prepared water demand projections through buildout of MPMW;
- Summarized existing water supplies and evaluated potential graywater use or recycled water use to provide a supplemental supply for MPMW;
- Developed and calibrated a new all-pipe hydraulic model for the MPMW system using the updated GIS water system features;
- Developed performance and operational criteria under which the water system was analyzed and facilities improvements formulated;
- Evaluated existing and buildout water system conditions for normal operations, emergencies and water quality scenarios to identify deficiencies and needed improvements;
- Conducted a system-wide condition assessment to develop recommendations for long-term renewal and replacement program needs;
- Prepared a seismic vulnerability assessment (VA) to identify improvements to reduce system seismic vulnerabilities;
- Conducted an advanced meter infrastructure (AMI) evaluation to summarize options for MPMW to implement an advanced meter reading (AMR) or AMI program;
- Evaluated operational and maintenance activities and developed recommendations for a long-term maintenance program and for optimizing water system operation;
- Developed a capital improvement program for recommended existing and future water system facilities.

The resulting WSMP provides a comprehensive road map for MPMW future planning.

1.2 AUTHORIZATION

West Yost Associates (West Yost) was authorized to prepare this WSMP by the City of Menlo Park (City) on June 23, 2015.

1.3 REPORT ORGANIZATION

This WSMP is organized into the following chapters:

- Chapter 1: Introduction
- Chapter 2: Existing Water System
- Chapter 3: Water Demands
- Chapter 4: Water Supplies
- Chapter 5: Planning and Design Criteria
- Chapter 6: Hydraulic Model Development
- Chapter 7: Existing Water System Evaluation
- Chapter 8: Future Water System Evaluation
- Chapter 9: Recommended Capital Improvement Program
- Chapter 10: System Operations and Maintenance Evaluation

The following appendices to this WSMP contain additional technical information, assumptions, and calculations:

- Appendix A: Final Submittal for Water System Geographic Information System Update
- Appendix B: Hydrant Testing for Model Calibration
- Appendix C: Menlo Park Seismic Vulnerability Assessment, Don Ballantyne, Ballantyne Consulting LLC, July 2017
- Appendix D: Advanced Metering Infrastructure Evaluation Draft Technical Memorandum, September 27, 2017
- Appendix E: Minimum Site Requirements for Storage Tanks
- Appendix F: Cost Estimating Assumptions
- Appendix G: Review of MPMW Staffing Assessment Findings March 2017

1.4 ACKNOWLEDGMENTS

The development of this WSMP would not have been possible without the key involvement and assistance of MPMW staff. In particular, the following staff provided comprehensive information, significant input and important insights throughout the development of this WSMP:

- Azalea Mitch, City Engineer and Water System Master Plan Project Manager
- Justin Murphy, Public Works Director
- Luis Olivera, Water System Supervisor
- Carlos Castro, Water System Supervisor

The following team members contributed to the WSMP:

- Charles Duncan, Principal In Charge
- Polly Boissevain, Project Manager
- Bobby Vera, Project Engineer
- Dakari Barksdale, Staff Engineer
- Don Ballantyne, Ballantyne & Associates, Seismic Vulnerability Assessment
- Eric Michel, Mapping Team Lead
- Mandy Ott, GIS Updates
- Monique Day, Supply Analysis Lead
- Lani Good, Condition Assessment Lead
- Nasim Shojaei, Condition Assessment
- Ty Tadano, AMI Evaluation Lead
- Courtney Hall, AMI Evaluation
- Kristen Whatley, Operating and Maintenance Review Lead
- Vicki Whitlock, Administrative Support
- Cynthia Paredes, Administrative Support

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This chapter describes MPMW's existing water distribution system. Water system information was obtained through the review of previous reports, maps, plans, operating records, and other available data provided to West Yost by MPMW. The following sections of this chapter describe the components of MPMW's existing water distribution system:

- Water Service Area
- System Configuration and Pressure Zones
- Water System Facilities

2.1 WATER SERVICE AREA

MPMW is located within the City, along the San Francisco Peninsula as shown on Figure 2-1. MPMW provides water service to approximately half of the City. California Water Service (Cal Water) provides service to the other half of the City, known as the Bear Gulch District, which roughly serves the core/middle of the City. Small portions of the City are served by the O'Connor Tract Co-operative Water Company, which provides service to343 households, and the Palo Alto Park Mutual Water Company, which provides service to about ten (10) households.

The MPMW water service area also includes the Menlo Park City School District – Laurel School Upper Campus and 10 properties on the west side of Euclid Avenue, all located in the Willows neighborhood within the City limits. Although the school and the residential properties are part of the MPMW service area, they are physically served by the City of East Palo Alto water system. Originally part of the East Palo Alto County Waterworks District, the properties were transferred to MPMW in 2001. During that time, an agreement was made between San Mateo County (County), the City of East Palo Alto and the City to leave the existing water system physically intact. MPMW handles the water billing for these properties and reimburses the City of East Palo Alto for the cost of providing service.

The MPMW water service area is approximately nine square miles, and provides water for potable uses, irrigation, and fire protection to its customers. Land uses throughout the water service area consist primarily of residential, commercial and industrial land uses. Land uses within the service area are discussed in more detail in Chapter 3.

2.2 SYSTEM CONFIGURATION AND PRESSURE ZONES

MPMW's sole source of supply is wholesale surface water purchased from the San Francisco Public Utilities Commission (SFPUC) via the SFPUC Regional Water System (RWS). Water is supplied to MPMW via five SFPUC turnouts, and is subsequently distributed to its customers within the different pressure zones via MPMW's various water system facilities. MPMW's water supply is discussed in more detail in Chapter 4.

MPMW operates three pressure zones: the High Pressure Zone, the Lower Zone, and the Upper Zone. The High Pressure Zone and Lower Zone are adjacent to each other, and are in the northeast part of the City, along the San Francisco Bay. Though these zones are adjacent to each other, they are hydraulically isolated under normal operations. The High Pressure Zone is supplied from the SFPUC system without pressure regulation to the zone. Historically, the High Pressure zone was predominantly comprised of industrial customers, which preferred higher than normal operating pressures. More recently, land has re-developed with commercial, office and high density residential land uses. Although pressure needs for normal operations are lower, many customers have fire sprinkler systems that have been designed for high pressure. The Lower Zone is supplied by three pressure regulating stations to reduce pressures from the SFPUC RWS. The Upper Zone is in the southwest portion of the City, near Interstate 280 and adjacent to the Coast Range hills. Because the Upper Zone is geographically isolated, there is no direct hydraulic connection between the Upper Zone and the High Pressure/Lower Zones. Table 2-1 provides a summary of these pressure zones with their key characteristics. The table summarizes the pressure zone name, range of customer service elevations, the hydraulic grade line (HGL) of the zone, the range of static service pressures and the source(s) of supply for the zone. The HGL lists the water surface elevation, in feet, that establishes zone static pressures. For the Lower Zone, the HGL is calculated based on the highest downstream pressure setting at the Burgess PRV station, which is the primary station supplying the zone. For the Upper Zone, the HGL is based on the overflow elevation of the Sand Hill Reservoirs. For the High Pressure Zone, the HGL is the estimated typical water surface elevation at the turnout supplying the zone. The static pressures, which represent pressures under no flow conditions, are calculated by taking the zone HGL, subtracting the customer elevations, and converting this value to pressure.

Figure 2-2 shows a plan view of MPMW's distribution system, pressure zones, and key water system facilities.

Table 2-1. Summary of Existing Pressure Zones

Pressure Zone	Range of Service Elevations[a], feet mean sea level (msl)	HGL of Reservoir, Pressure Regulating Station, or Turnout[b], feet msl	Range of Static Service Pressures[c], psi	Water Supply Sources
Lower Zone	0 – 97	213	50 – 93	SFPUC (Turnouts 15, 14, 73) and associated pressure regulating valve stations
High Pressure Zone	0 – 14	320	132 – 139	SFPUC via Turnout 13
Upper Zone	167 – 358	492	58 – 141	SFPUC via the Sharon Heights Pump Station

(a) Elevations based on meter information from system-wide field verification data collected with GPS unit.
(b) For the Lower Zone, the HGL is based on a nominal gradient calculated from the primary Burgess PRV. For the High Pressure Zone, the HGL is based on an average SFPUC pressure of 132.5 psi at the turnout and at an elevation of 13 feet msl. For the Upper Zone, the HGL is based on the overflow elevation of the Sand Hill Reservoirs.
(c) Calculated based on the HGL minus the highest or lowest customer service elevation within the zone.

2.3 WATER SYSTEM FACILITIES

MPMW's key water system facilities (turnouts, pressure regulating valve stations, reservoirs, booster pump stations, pipelines, etc.) are discussed in more detail in the sections below. Figure 2-2 shows a plan view of MPMW's distribution system, pressure zones, and key water system facilities. Figure 2-3 provides an overall schematic diagram of MPMW's existing water system. The evaluation of facility capacities and their ability to meet existing and future demands is described in Chapters 7 and 8.

2.3.1 SFPUC Turnouts

MPMW receives all of its water from SFPUC though five turnouts located on the SFPUC Bay Division Pipelines (BDPLs) and the Palo Alto Pipeline. These turnouts are shown on Figure 2-2 and summarized in Table 2-2 below. Turnouts 14, 15 and 73 supply the Lower Zone, MPMW's largest pressure zone. Each of these turnouts are connected to pressure reducing stations, which regulate pressure to the Lower Zone. The High Pressure Zone is served directly by Turnout 13. Since this turnout supplies the High Pressure zone directly, this turnout is unregulated and there is no subsequent pressure reducing valve station. The Upper Zone is served by Turnout 61, which is located on Sharon Park Drive. Supply from this turnout is used to fill the Sand Hill Reservoirs via the Sharon Park Pump Station.

Table 2-2. Summary of Existing SFPUC Turnouts [(a)]

Turnout No. and Name	Connection Address	Turnout Pipeline Diameter, inches	Operating Pressure Range, psi[(b)]	Source	Service Zones	Notes
73 Burgess	650 El Camino Real	8	108 – 145	Palo Alto PL	Lower Zone	Regulated, serves the Burgess PRV Station
15 Chilco	455 Ivy Drive	8	120 – 145	BDPLs No. 1 and No. 2	Lower Zone	Regulated, serves the Chilco PRV Station
14 Madera	785 Ivy Dr.	8	120 – 145	BDPLs No. 1 and No. 2	Lower Zone	Regulated, serves the Madera PRV Station
13 Hill	216 Ivy Drive	8	120 – 145	Bay Division Pipelines (BDPLs) No. 1 and No. 2	High Pressure Zone	Unregulated, supplies the High Pressure Zone directly
61 Sharon Park	920 Sharon Park Drive	8	35 – 50	BDPLs No. 3 and No. 4	Upper Zone	Unregulated, serves the Sharon Heights Pump Station

(a) Sources: Site Visits 8/20/2015 and 8/25/2015; Water System Evaluation Report (Metcalf & Eddy, 2000)
(b) Operating pressure is pressure from SFPUC. For turnouts with a PRV station, pressure settings for the PRV's are reported in Table 2-3.

2.3.2 Pressure Reducing Stations

MPMW's water distribution system includes three pressure reducing valve stations (PRV stations), all of which are located downstream of SFPUC turnouts within the Lower Zone as shown on Figure 2-2. The purpose of the PRV stations is to regulate water pressure from the SFPUC system (high pressure) to MPMW's Lower Zone (low pressure), keeping the system pressure from exceeding practical limits. Table 2-3 presents a summary of the existing PRV stations with their key characteristics. It should be noted that the primary PRV station for the Lower Zone is the Burgess PRV station because current settings at the station result in a hydraulic grade much greater than the Madera and Chilco PRV stations. The pressure settings at the Madera and Chilco PRV stations were lowered to avoid flooding customers in the Bayfront area. As a result, the Burgess PRV station has become the primary supply to the Lower Zone, because the settings at this station were not lowered, and has supplied between 59 to 95 percent of the total Lower Zone demand since 2011. Refer to Chapter 7 for additional discussion and proposed recommendations to address this issue.

2.3.3 Water Storage Facilities

MPMW has two water storage facilities, the Sand Hill Road Reservoirs, which supply the Upper Zone, as shown on Figure 2-2. The reservoirs are located next to one another and are adjacent to The Horse Park at Woodside, west of Interstate 280 along Sand Hill Road, on property leased from Stanford University. Both reservoirs are open cut, concrete lined, and are interconnected with one another so that they float at the same water surface elevation. Water is pumped from the Sharon Heights Pump Station into Reservoir 2, which then moves into Reservoir 1 and subsequently supplies the Upper Zone. Though the reservoirs are normally operated together in the manner described above, there are sufficient valves to isolate reservoirs to either operate reservoirs independently or to take a reservoir out of service. Based on discussions MPMW Operations staff, water surface levels are typically maintained between 9 feet and 18 feet in the summer, and 8 feet and 12 feet in the winter. Table 2-4 summarizes the Sand Hill Road reservoirs with their key characteristics.

2.3.4 Booster Pump Station

MPMW's water system currently operates one pump station, the Sharon Heights Pump Station (PS). The Sharon Heights PS is supplied from SFPUC Turnout 61, and pumps to the Sand Hill Reservoirs, which supply the Upper Zone. MPMW operates the Sharon Heights PS based on the Sand Hill Reservoir levels. The pump station has three pumps, with two duty pumps and one standby pump. According to MPMW, the actual capacity with two pumps operating is about 2,800 gpm. The pump station is equipped with an onsite backup generator to provide emergency power to the pumps during a power outage. Table 2-5 presents a summary of the Sharon Heights PS with its key characteristics.

Table 2-3. Summary of Existing Pressure Reducing Valve Stations[a]

PRV Station	Associated Turnout No.	Location	Valve Diameter, inches	Elevation[b], Feet msl	From	To	Upstream Pressure Range, psi	Downstream Pressure Setting, psi	Calculated Hydraulic Gradient[c], feet msl
Burgess PRV	73	701 Laurel Street, near Burgess Park	4	63	SFPUC	Lower Zone	108 - 145	65	213
			8	63				58	197
Chilco PRV	15	Median of Ivy Drive, near Chilco St	4	11	SFPUC	Lower Zone	120 - 145	65	161
			8	11				65	161
Madera PRV	14	Median of Ivy Drive, near Madera Avenue	4	13	SFPUC	Lower Zone	120 - 145	65	163
			8	13				65	163

(a) Sources: Site Visits 8/20/2015 and 8/25/2015.

(b) Elevation measured during system-wide field verification of the District's water system by West Yost using a hand-held GPS unit and rounded to the nearest foot.

(c) Calculated by using GPS measured elevations; HGL = Elevation + (Downstream Pressure) * 2.31.

Table 2-4. Summary of Existing Storage Facilities[a]

Storage Facility Name	Pressure Zone	Reservoir Type[b]	Reservoir Shape	Year Constructed	Base Elevation, feet	Overflow Elevation, feet	Maximum Operating Level (Overflow), feet	Minimum Operating Level, feet[c]	Nominal Storage Capacity, MG
Sand Hill Reservoir 1 (W)	Upper Zone	Open Cut, Concrete Lined and Covered	Trapezoidal	1960	474	492	18	1.9	2.0
Sand Hill Reservoir 2 (E)				1996	474	492	18	1.9	3.5

[a] Source: Site Visits 8/20/2015 and 8/25/2016 and As-Built Drawings (BKF, 2000).

[b] From Seismic Vulnerability Assessment (G&E Engineering Systems Inc., 2004).

[c] Based on the invert elevation of outlet pipe (BKF, 2000).

Table 2-5. Summary of Existing Pumping Facilities

Pump Station	Source	Service Pressure Zone	Ground Surface Elevation[a], feet msl	Pump No.	Horsepower	Rated Total Dynamic Head[b], feet	Rated Pump Capacity[c], gpm
Sharon Heights PS[c]	SFPUC Turnout No. 61	Upper Zone	227.5	1	100	200	1,550
				2	100	200	1,550
				3	100	200	1,550

[a] From design drawings by Carollo Engineers (April 2013).

[b] From Pump Curves/Performance By Pacific Water Resources (8/6/2014). The static discharge pressure is approximately 46 psi. The discharge pressure increases to approximately 133 psi with one pump operating.

[c] Bowl Size/Type: 12EN; Impeller Diameter: 9.7 inches, Curve No. EC-1389, Number of Stages: 4. Two pumps operate with a combined discharge of approximately 2,800 gpm.

2.3.5 Emergency Interconnections

MPMW has emergency interconnections with four adjacent water suppliers: Cal Water, City of East Palo Alto, City of Redwood City, and O'Connor Tract Co-operative Water Company. The emergency interconnections with their key characteristics are summarized in Table 2-6 and are shown on Figure 2-2.

2.3.6 Emergency Groundwater Wells

Currently, MPMW does not use any groundwater supplies. However, MPMW has undertaken a multi-year Emergency Water Supply Program to provide a local back-up source of emergency supply to the Lower Zone, if SFPUC supply is not available. This program is discussed in more detail in Chapter 4. The first project as part of this program is the proposed Corporation Yard Emergency Back-up Water Supply Well No. 1 (Well 1). MPMW is currently completing the installation of Project, which is sited at MPMW's Corp Yard within the Lower Zone. The expected yield of Project is 1,500 gpm and well construction will be completed by the end of 2018. One or more additional wells are planned to achieve a total supply capacity of 3,000 gpm. The 3,000 gpm goal was recommended by City staff as the approximate flow needed to meet the average day demand of 1,600 gpm plus the reduced fire flow of 1,500 gpm.

2.3.7 Other Distribution System Features

2.3.7.1 Pipelines

Table 2-7 and Table 2-8 summarize MPMW's existing pipelines by diameter and material type, respectively. MPMW existing water system consists of approximately 55[1] miles of water system pipelines. Distribution pipelines sizes generally range from 2 to 10-inches in diameter, while larger transmission mains range from 12 to 18-inches in diameter. As shown, most of these pipelines are smaller distributions mains consisting 6 to 8-inches in diameter, typically made of asbestos cement (AC).

2.3.7.2 Hydrants

Table 2-9 summarizes the number of hydrants. The table notes whether hydrants are dry-barrel, wet-barrel, or their type is unknown. Hydrant information is based on the field data collection program conducted in Fall 2015, which included use of GPS hand-held units to verify location of hydrants, valves and meters.

[1] This total includes MPMW-owned main lines, which excludes laterals. Previous reports have reported total pipeline lengths of 80 miles, which include all pipelines (main lines and laterals) and may also have included non-MPMW owned pipelines.

Table 2-6. Summary of Existing Intertie Locations

Intertie Connection Location	Pressure Zone	Connection Type	Metered	Diameter, inches	Remarks
East Palo Alto					
O'Brien Drive and Kavanaugh Drive	Lower	Hard Piped, Closed Valved	-	10	Three total connections/ valves in the vicinity are closed
O'Brien Drive and University Avenue	Lower	Hard Piped, Closed Valved	-	12	Two total connections/valves within the vicinity are closed
University Drive south of O'Brien Drive	Lower	Hard Piped, Closed Valved	-	10	-
Adams Drive and University Avenue	Lower	Hard Piped, Closed Valved	-	12	-
Willow Road and Ivy Drive	Lower	Hard Piped, Closed Valved	-	12	-
Willow Road and Newbridge Street	Lower	Hard Piped, Closed Valved	-	12	-
Cal Water					
Middlefield Road and Seminary Drive	Lower	Hard Piped, Closed Valved	Yes	12	-
Chrysler Drive and Commonwealth Drive	High Pressure	Hard Piped, Closed Valved	-	12	-
Avy Avenue and Altschul Avenue	Upper	Hydrant-to-Hydrant	-	N/A	-
City of Redwood City					
Haven Avenue and E Bayshore Road	High Pressure	Hydrant-to-Hydrant	-	N/A	-
O'Connor Tract Co-Operative Water Company					
Walnut Street and Menalto Avenue	Lower	Hard Piped, Closed Valved	Yes	8	-

Table 2-7. Summary of Existing Pipelines by Diameter[a,b]			
Pipe Diameter	Length of Pipelines, feet	Length of Pipelines, miles	Percent in Water System
UNK	8,920	1.7	3
2	10	0.0	0
3	250	0.0	0
4	8,230	1.6	3
6	86,450	16.4	30
8	99,520	18.8	34
10	31,570	6.0	11
12	42,800	8.1	15
14	280	0.1	0
16	11,930	2.3	4
18	150	0.0	0
Total	**290,110**	**54.9**	**100%**

(a) Includes MPMW-owned active pipelines within MPMW service area, contained in the Water Main shapefile provided by MPMW. Service laterals are not included.
(b) Pipeline lengths rounded to the nearest 10 feet.

Table 2-8. Summary of Existing Pipelines by Material[a,b]				
Material Designation	Acronym	Length of Pipelines, feet	Length of Pipelines, miles	Percent in Water System
Asbestos Cement	AC	144,790	27.4	50%
Cast Iron	CI	4,650	0.9	2%
Ductile Iron (DI)	DI	90,720	17.2	31%
Earthquake Resistant Ductile Iron (ERDI)	ERDI	2,780	0.5	1%
High Density Polyethylene (HDPE)	HDPE	490	0.1	0%
Polyvinyl Chloride	PVC	20,830	3.9	7%
Steel	Steel	60	0.0	0%
Unknown	UNK	25,790	4.9	9%
	Total	**290,110**	**54.9**	**100%**

(a) Includes MPMW-owned active pipelines within MPMW service area, contained in the Water Main shapefile provided by MPMW. Service laterals are not included.
(b) Pipeline lengths rounded to the nearest 10 feet.

Table 2-9. Summary of System Hydrants [(a)]	
Hydrant Type	Number of Hydrants
Wet-Barrel	142
Dry-Barrel	228
Not Defined	8
Total	**378**

(a) Hydrant information based on Fall 2015 field data collection program.

2.3.7.3 Valves

MPMW has approximately 1120 isolation valves in its system. The estimate of the number of valves is based on the field data collection program conducted in Fall 2015. The estimate includes only system valves, not hydrant shutoff valves. Table 2-10 summarizes the number of valves by type and diameter.

Table 2-10. Summary of System Valves [(a)]				
Valve Type	≤8-inch	>8-inch	Not Defined	Total
Gate	728	145	89	962
Butterfly	13	143	0	156
Not Defined	1	0	0	1
Total	**742**	**288**	**89**	**1,119**

(a) System valve information based on Fall 2015 field data collection program. Valves include in-line valves only. Hydrant shutoff valves are not included in the above totals.

2.3.7.4 Meters

Table 2-11 summarizes the number of customer service meters, by size and pressure zone. The estimate of the number of meters is based on the field data collection program conducted in Fall 2015.

Table 2-11. Summary of Customer Meters [(a)]

Meter Size	Lower Zone	High Pressure Zone	Upper Zone	Total
5/8"	2,642	24	267	**2,933**
3/4"	11	0	2	**13**
1"	191	30	409	**630**
1-1/2"	25	46	23	**94**
2"	68	17	36	**121**
3"	5	4	9	**18**
4"	3	3	1	**7**
6"	2	0	0	**2**
Not Defined	63	33	89	**185**
Total	**3,010**	**157**	**836**	**4,003**

(a) Customer meter information based on Fall 2015 field data collection program. MPMW billing records report 4355 customer connections as of 2015, 136 of which are unmetered private fire connections, and 27 of which are hydrant construction meter accounts. Field survey included all accessible meter locations, except those on Sand Hill Road, west of 280.

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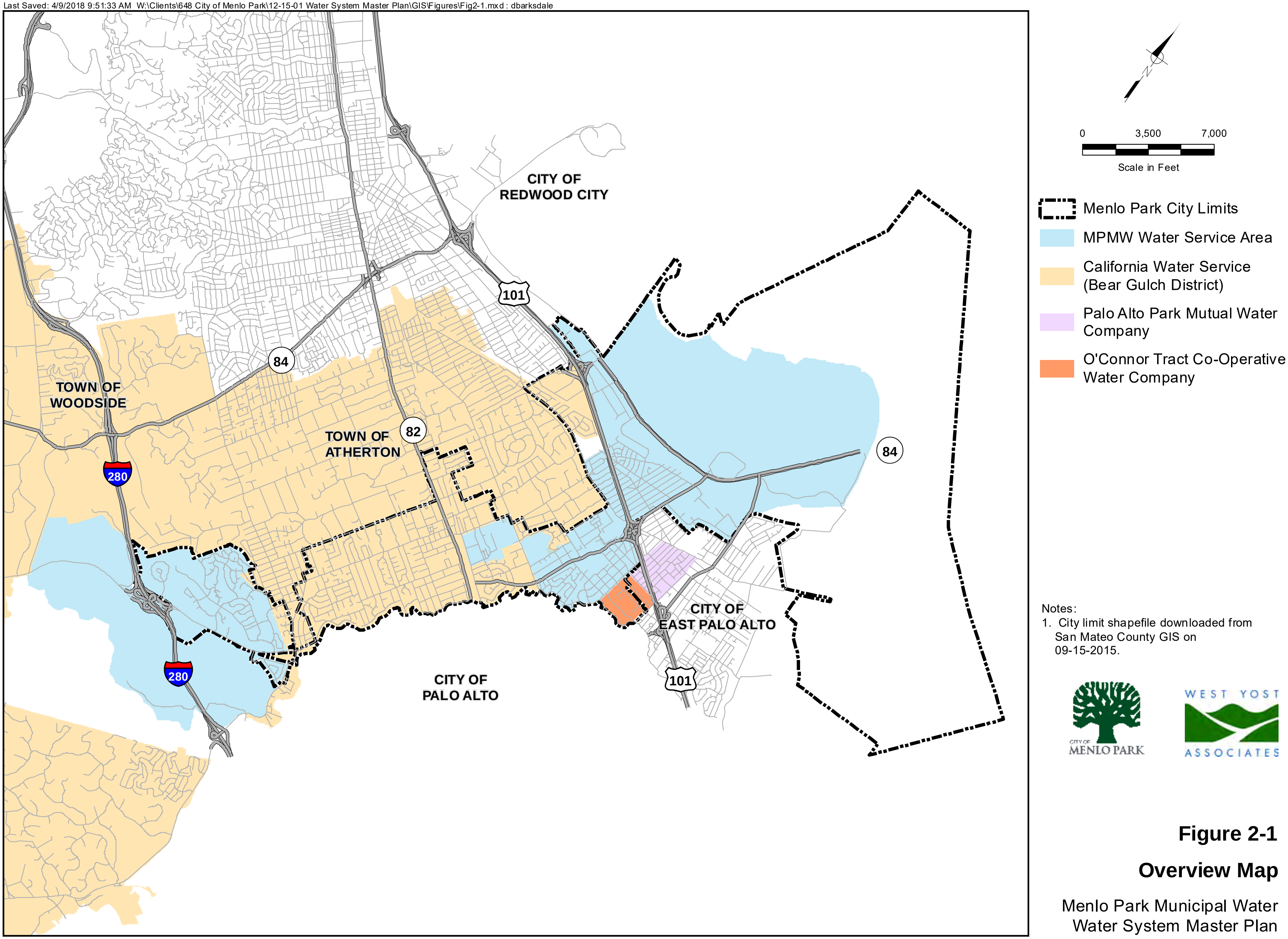

Notes:
1. City limit shapefile downloaded from San Mateo County GIS on 09-15-2015.

CITY OF MENLO PARK

WEST YOST ASSOCIATES

Figure 2-1

Overview Map

Menlo Park Municipal Water
Water System Master Plan

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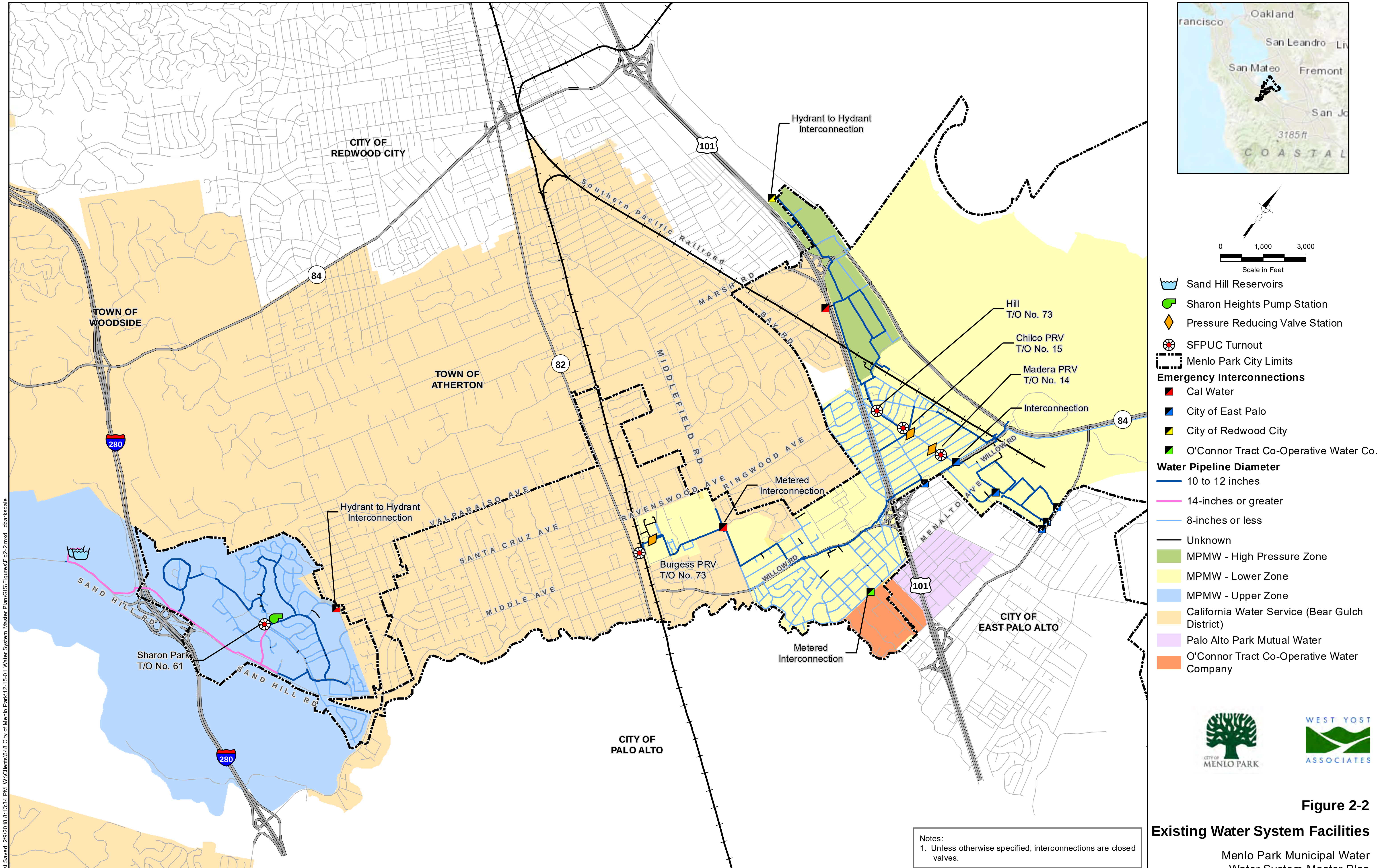

Figure 2-2

Existing Water System Facilities

Menlo Park Municipal Water
Water System Master Plan

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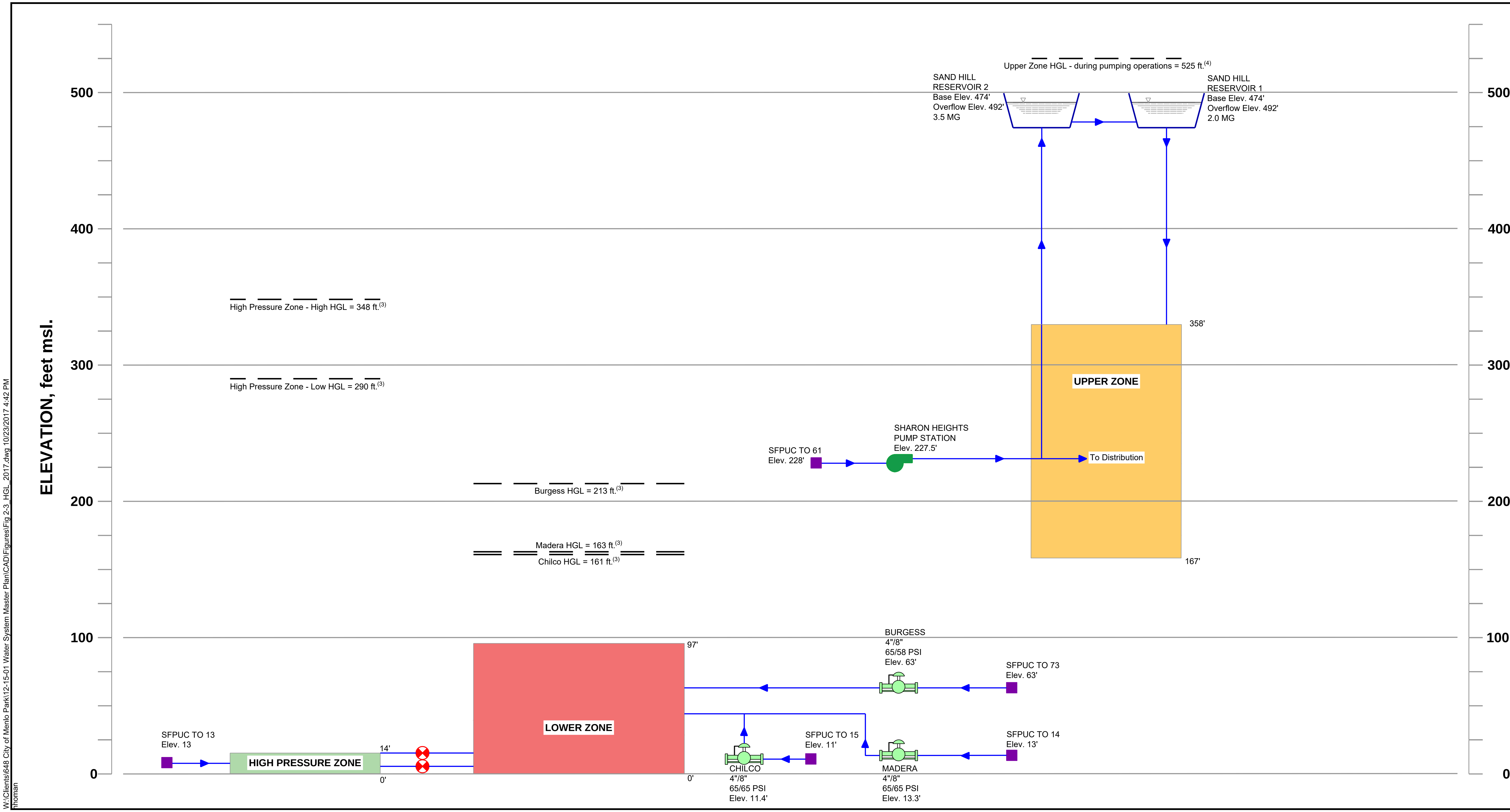

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LEGEND

- Turnout
- Pressure Reducing Station
- Closed Valve
- Booster Pump Station
- Water Storage Reservoir

Notes:
1. Elevations based on field collected data from system-wide field verification.
2. Interconnections between MPMW and other water providers not shown.
3. Basis for HGL calculations is summarized on Table 2-1.
4. The HGL during the pumping operations is based on HGL during 7/6/2015 - 7/9/2015 field tests with two pumps operating at the Sharon Heights PS. HGL may be higher or lower based on system conditions.

CITY OF MENLO PARK

WEST YOST ASSOCIATES

Figure 2-3

Existing System
Schematic Hydraulic Profile

Menlo Park Municipal Water
Water System Master Plan

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CHAPTER 3
Water Demands

This chapter provides an overview of MPMW's water service area and describes MPMW's historical annual water use. Subsequent sections of this chapter examine water conservation and historical peak water use. Finally, this chapter describes the data and methodologies used to develop future water delivery projections. The key sections of the chapter are:

- Service Area Description
- Historical Annual Water Deliveries and Consumption
- Peak Water Use
- Water Conservation
- Future Water Delivery Projections

Future water delivery projections developed in this chapter were allocated to the hydraulic model to evaluate system performance for 2040 maximum day and peak hour conditions, as described in Chapter 8.

3.1 SERVICE AREA DESCRIPTION

This section summarizes the City's service area, population, and service connections.

3.1.1 Service Area Overview

MPMW serves approximately half of the City. The remainder of the City is served by California Water Service's Bear Gulch District, the O'Connor Tract Co-operative Water Company, which serves a small area, and the Palo Alto Park Mutual Water Company, which serves fewer than ten homes on the eastern side of the City. Figure 2-1 shows the MPMW service area.

3.1.2 Historical Population

Table 3-1 summarizes the historical population for the service area, from 1996 through 2015. The service area population slightly declined from 2001 through 2005, but has steadily grown every year since. In the 10-year period from 2006 through 2015, the service population grew by a total of 9 percent.

3.1.3 Number of Service Connections

Table 3-2 summarizes the number of customer services, for 2011 through 2015. There were 4,355 service connections as of 2015. Of these, 136 are unmetered private fire connections and 27 are hydrant construction meter accounts. Residential users account for 83 percent of all service connections. Of the remaining 17 percent of non-residential users, the largest customer sector is industrial connections with 6 percent, while commercial service connections make up 4 percent and irrigation accounts for 3 percent. The 'Other' category includes temporary services and sales (e.g., construction meters), private fire services and hydrant services.

Table 3-1. Historical Service Area Population[a]	
Year	Distribution System Population
1996	13,655
1997	13,777
1998	13,970
1999	14,059
2000	14,164
2001	14,224
2002	14,196
2003	14,102
2004	14,067
2005	13,997
2006	14,059
2007	14,171
2008	14,390
2009	14,612
2010	14,749
2011	14,829
2012	14,973
2013	15,129
2014	15,157
2015	15,342

(a) Source: 2015 UWMP, Appendix F, Table 3 (1996 through 2010) and Chapter 3, Table 3-1 (2011 through 2015).

Table 3-2. Historical Number of Service Connections by Customer Sector in the Service Area[a]

Customer Sector	2011	2012	2013	2014	2015
Number of Connections					
Single Family Residential	3389	3389	3389	3390	3393
Multi-Family Residential	210	210	210	210	210
Subtotal Residential	3599	3599	3599	3600	3603
Commercial	157	160	162	161	172
Industrial	252	252	251	243	245
Public Authority	37	38	38	38	38
Irrigation/Landscape	134	133	132	132	135
Other	141	149	154	155	162
Subtotal Non-residential	721	732	737	729	752
Total, all Customers	**4320**	**4331**	**4336**	**4329**	**4355**
Percent of Total Connections					
Single Family Residential	78%	78%	78%	78%	78%
Multi-Family Residential	5%	5%	5%	5%	5%
Subtotal Residential	83%	83%	83%	83%	83%
Commercial	4%	4%	4%	4%	4%
Industrial	6%	6%	6%	6%	6%
Public Authority	1%	1%	1%	1%	1%
Irrigation/Landscape	3%	3%	3%	3%	3%
Other	3%	3%	4%	4%	4%
Subtotal Non-residential	17%	17%	17%	17%	17%
Total, all Customers	**100%**	**100%**	**100%**	**100%**	**100%**

[a] Source: Annual Consumption by Month by Customer Spreadsheets from Menlo Park MWD. Commercial category includes Business and Commercial billing classes. Irrigation/Landscape includes Farm Irrigation, Irrigation Commercial and Irrigation/Landscape billing classes. Other includes Other - Sales & Service, Private Fire and Hydrant services.

3.2 HISTORICAL ANNUAL WATER DELIVERIES AND CONSUMPTION

This section summarizes MPMW's historical water deliveries, consumption, water losses, and per capita water use.

3.2.1 Water Deliveries

SFPUC water is MPMW's sole source of drinking water, delivered from the SFPUC RWS. This water is supplied to MPMW predominantly through the Hetch Hetchy aqueduct system from the Sierra Nevada. This supply is also supplemented by SFPUC facilities in its local watershed in Alameda County. The sale of water from SFPUC to MPMW is governed by a water supply agreement (WSA) between SFPUC and its wholesale customers in Alameda County, San Mateo County, and Santa Clara County.

Table 3-3 shows monthly and annual SFPUC water supply purchased and delivered to MPMW. The annual water supplies delivered to MPMW remained somewhat steady from 2001 through 2013, followed by a decline in 2014 and 2015, due to reduced usage during the recent drought.

Table 3-3. Historical Monthly Water Purchases from SFPUC, Million Gallons[(a)]

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
2001	68	61	58	95	112	152	156	165	162	118	104	66	1316
2002	66	72	73	91	129	156	157	148	160	127	101	68	1349
2003	60	67	63	84	80	155	166	156	166	165	112	66	1341
2004	75	68	67	119	147	151	172	150	167	125	75	71	1386
2005	69	60	61	90	97	146	174	149	167	132	88	73	1306
2006	72	63	61	64	85	136	197	145	155	104	90	54	1228
2007	62	62	60	105	114	151	202	163	154	115	99	71	1357
2008	65	73	67	110	123	150	154	148	146	128	89	59	1311
2009	60	62	53	81	126	113	144	151	139	119	86	62	1196
2010	61	51	54	67	92	118	148	140	145	116	73	58	1123
2011	60	58	60	79	97	114	135	120	119	114	85	79	1121
2012	74	71	85	83	106	138	139	142	132	100	74	60	1202
2013	46	61	77	87	123	147	181	171	184	112	91	69	1349
2014	64	73	49	68	115	116	123	113	82	84	86	47	1021
2015	64	57	64	79	87	78	97	87	82	87	58	47	886
2016	44	42	45	60	69	87	112	101	104	83	54	49	851

(a) Source: Monthly Purchase Spreadsheets received from Menlo Park MWD. Annual totals may differ from the sum of the monthly volumes due to rounding.

The City's largest monthly water purchases have typically occurred in July, and the lowest monthly water purchases have occurred between December and March, as would be expected, based on seasonal rainfall and temperature patterns.

3.2.2 Water Consumption

Table 3-4 summarizes historical annual metered water consumption from 2011 to 2015. Within this time-period, water consumption peaked in 2013 at 1,160 million gallons (MG) before declining to a low of 855 MG in 2015. Residential water consumption has ranged from 43 percent to 49 percent of total consumption, averaging 46 percent of total consumption. About 75 percent of residential consumption is single family residential use. Non-residential water consumption comprises 54 percent of the total water usage. Industrial water consumption is the largest non-residential use, accounting for about 40 percent of the non-residential water consumption and 20 percent of the total water consumption.

Table 3-4. Historical Annual Water Consumption, Million Gallons[a]

Customer Sector	Year				
	2011	2012	2013	2014	2015
Residential					
Single Family	376	387	402	354	275
Multi-Family	115	119	118	106	92
Subtotal Residential	491	506	520	460	367
Non-Residential					
Commercial	141	150	176	184	168
Industrial	241	217	231	215	186
Public Authority	52	66	63	50	38
Irrigation/Landscape	83	137	167	117	93
Other	0	1	3	5	3
Subtotal Non-Residential	517	571	640	570	489
Total	**1009**	**1077**	**1160**	**1031**	**855**
Percent Residential	49%	47%	45%	45%	43%
Percent Non-Residential	51%	53%	55%	55%	57%

[a] Source: Annual Consumption by Month by Customer Spreadsheets from MPMW. Commercial uses include Business and Commercial billing customer sectors; Irrigation/Landscape includes Farm Irrigation, Irrigation Commercial and Irrigation/ Landscape billing customer sectors; other includes temporary construction uses, private fire and hydrant metering.

3.2.3 Water Losses

System water loss is the difference between the quantity of water purchased and the quantity of water consumed. Water loss is defined as the sum of unbilled authorized consumption (water for firefighting, flushing, etc.), apparent loss (customer meter inaccuracies, unauthorized consumption and data error), and real losses (system leakage and storage tank overflows).

The City's annual water production, water consumption, and water losses are summarized in Table 3-5. In the last five years, the non-revenue water has ranged from 0 percent to 14 percent of total water deliveries, with an average of 6 percent.

Table 3-5. Historical Water Loss

Calendar Year	Water Deliveries, MG/year [a]	Water Consumption, MG/yr	Water Loss, MG/yr	Percent of Water Deliveries
2011	1082	1009	73	7%
2012	1190	1077	113	9%
2013	1345	1160	184	14%
2014	1020	1031	(11)	-1%
2015	884	855	29	3%
			Average	**6%**

[a] Water deliveries are total deliveries to MPMW system less deliveries to East Palo Alto system

3.2.4 Per Capita Water Use

Table 3-6 and Figure 3-1 show population and water production trends, and the computed per capita water use. The peak per capita water use was 269 gallons per capita per day (gpcd) in 2004. Since 2006, per capita water use has been declining, ranging from 262 gpcd (2006) to 158 gpcd (2015).

Table 3-6. Historical Per Capita Water Use			
Calendar Year	Distribution System Population[a]	Water Delivery, mgd[b]	Per Capita Water Use, gpcd
1996	13,655	3.37	247
1997	13,777	3.63	263
1998	13,970	3.22	230
1999	13,059	3.49	248
2000	14,164	3.71	262
2001	14,224	3.60	253
2002	14,196	3.69	260
2003	14,102	3.67	260
2004	14,067	3.78	269
2005	13,997	3.57	255
2006	14,059	3.36	239
2007	14,171	3.71	262
2008	14,390	3.58	249
2009	14,612	3.27	224
2010	14,749	3.07	208
2011	14,829	3.07	207
2012	14,973	3.28	219
2013	15,129	3.69	244
2014	15,157	2.79	184
2015	15,342	2.43	158

[a] Source: 2015 Urban Water Management Plan
[b] Source: SFPUC water purchase data.

3.3 PEAK WATER USE

Water system facilities are generally sized to meet peak demands. The peaking conditions of most concern for water facility sizing are maximum day demand with fire flows and peak hour demand. Peak water use is typically expressed as a ratio, or peaking factor, dividing the peak water use by the average daily or maximum day water use. These peaking factors are then used to calculate maximum day and peak hour water use.

Historically, the City has only had access to monthly flow data for SFPUC turnouts, based on monthly meter readings collected to bill MPMW for its water usage. However, since 2015, SFPUC has provided wholesale customers on-line access to hourly delivery information by turnout. Information from 2016 was used to evaluate maximum day and peak hour water use, to develop peaking factors for use in the WSMP.

Table 3-7 summarizes maximum day and peak hour peaking factors by pressure zone. MPMW reviewed 2016 daily turnout data and provided daily turnout deliveries for July 2016, and hourly turnout deliveries for the maximum delivery day, which was July 25, 2016 for the Lower Zone and July 22, 2016 for the High Pressure Zone. Ultimately, the daily and hourly data were only used for the Lower Zone, and other methods were used to estimate peaking factors for the High Pressure Zone and Upper Zone, as further described below.

A review of the hourly deliveries for the High Pressure Zone on the maximum day indicated a very high usage over a short-duration, with a peak hour usage of about 4.0 times the maximum daily use. This usage pattern occurred at different times on consecutive days. Further investigation indicated that this large use was most likely attributable to usage by a former industrial manufacturing facility at a property that has since been acquired by Facebook and is currently being redeveloped. Based on currently-adopted zoning, it is anticipated that properties within the High Pressure Zone will be re-developed for a mix of office, residential and light industrial. Therefore, peaking factors for the Lower Zone, which includes a similar mix of uses, are recommended for use for the High Pressure Zone.

Turnout data could not be used to calculate the Upper Zone maximum day or peak hour use, because the Sand Hill Reservoirs are very large, so hourly reservoir flows to meet zone demands cannot accurately be estimated from reservoir level information. Maximum day usage for the Upper Zone was estimated by scaling up the maximum monthly usage by 15 percent, based on the ratio between the maximum month and maximum daily use for the Lower Zone. Peak hour use was estimated to be 2.0 times maximum daily use, based on a typical peaking factor for pressure zones with predominantly residential characteristics.

Table 3-7. Summary of Peaking Factors by Pressure Zone[(a)]

Pressure Zone	Average Day to Maximum Day Peaking Factor	Average Day to Peak Hour Peaking Factor
Lower Zone[(a)]	1.54	2.20
High Pressure Zone[(b)]	1.54	2.20
Upper Zone[(c)]	1.90	3.80

(a) Peaking factors based on daily and hourly meter data from SFPUC.
(b) Peaking factors based on Lower Zone, due to similar land use zoning.
(c) Upper Zone maximum day demand peaking factor based on the ratio of maximum month to average day, scaled up by an additional 15 percent, to account for daily variations. Peak hour factor is based on a maximum day to peak hour peaking factor of 2.0, consistent with areas largely comprised of residential land uses.

3.4 WATER CONSERVATION

This section summarizes the City's existing water conservation programs, and recent California regulations on water use efficiency that will impact MPMW's future water use.

3.4.1 MPMW Water Conservation Programs

The MPMW has been and continues to be a strong promoter of water conservation programs that improve water supply reliability and provide environmental benefits to the community. MPMW participates in Bay Area Water Supply and Conservation Agency's (BAWSCA) regional water conservation program, which includes subscription-based programs that member agencies can elect to participate in and fund. MPMW participates in all the available BAWSCA subscription programs, including high-efficiency toilet and washing machine rebates, school education kits and programs, large landscape audits and turf replacement rebates.

For new residential and non-residential development, the City requires that all new development comply with the mandatory California Green Building Code. The City also requires that new or rehabilitated landscapes for projects subject to City review and approval comply with the City's Water Efficient Landscaping Ordinance, which reflects the latest California State Model Water Efficient Landscape Ordinance.

In addition, through the City's General Plan Update efforts, the City passed water conservation measures for new development. New development within the Bayfront Area is required to be dual plumbed for internal use of recycled water. For buildings equal to or exceeding 100,000 sq. ft. in size, the City requires a development of a water budget. For buildings 250,000 sq. ft. and larger, the City requires identification and use of an alternate water source for all City approved non-potable applications (e.g., graywater).

3.4.2 State Regulations on Water Use Efficiency

The 2009 Water Conservation Act and Executive Order B-37-16 (Executive Order) establish water conservation targets for urban water users to increase water use efficiency in the future. Senate Bill 555 increases reporting requirements for calculating and reducing system water loss. These directives are summarized below.

3.4.2.1 2009 Water Conservation Act

The Water Conservation Act of 2009, also known as Senate Bill X7-7 established a statewide 20 percent reduction in urban per capita water use by 2020. The California Department of Water Resources (DWR), charged with implementing the act, developed methodologies for developing historical baseline usage and establishing per capita water use targets. Historical baseline information and per capita targets were first established for reporting in 2010 Urban Water Management Plans (UWMPs), and were refined for the 2015 UWMPs, using population data from the 2010 census. SB X7-7 requires urban water agencies to establish baseline usage, based on historical consumption, and then determine targets to reduce per capita consumption by 2020. DWR provides four methodologies to calculate water use targets, with agencies allowed to select the most favorable (i.e. highest per capita water use) methodology for establishing its water use target.

Based on calculations presented in the 2015 UWMP, MPMW's baseline use is 255 gpcd, with a 2015 interim water use target of 229 gpcd and a 2020 water use target of 204 gpcd. 2015 water use was 158 gpcd, which is well below the 2015 and 2020 water use targets, principally due to drought restrictions that reduced water use. Some rebound in water use is expected now that the drought is over. The 2015 UWMP projected a rebound in use to 201 gpcd by 2020.

3.4.2.2 SB 555 Urban Retail Water Suppliers: Water Loss Management

California Senate Bill 555, passed in October 2015, requires all urban retail water suppliers to submit completed and validated water loss audits annually to DWR, starting in October 2017. DWR published draft regulations and received public comment on the regulations in March and April 2017.

The regulations require urban water suppliers to conduct water loss audits in accordance with the American Water Works Association (AWWA) Manual of Water Supply Practices – M36, Water Audits and Loss Control Program. AWWA has developed free water audit software, and DWR will require on-line submission of water loss audits using this software. Water loss audits are required to have at least a Level 1 validation, which requires that audits be documented and corrected for inaccuracies that are evident at the summary level, and the utility confirm that the water audit methodology has been correctly applied. The California-Nevada section of the AWWA sponsored a Technical Assistance Program, funded by the State Water Resources Control Board (Water Board), to assist urban water suppliers in complying with the new requirements.

DWR will identify urban retail water suppliers with high water losses, based on evaluation of the water loss audits submitted in October 2017. Suppliers with high losses will be prioritized for technical assistance, with the aim of developing and implementing water loss reduction plans. In 2019 or 2020, the Water Board will adopt performance standards for water loss volumes. The Water Board will also identify compliance and enforcement mechanisms for water loss standards.

3.4.2.3 Executive Order B-37-16

In May 2016, Governor Edmund G. Brown, Junior, signed Executive Order, *Making Water Conservation a California Way of Life*. The Executive Order directed DWR to work with the Water Board to develop new water use targets as part of a permanent conservation framework for urban water agencies. The targets will build upon requirements established in the 2009 Water Conservation Act, but will strengthen standards for indoor residential per capita water use, outdoor irrigation, commercial, industrial and institutional (CII) water use, and water lost through leaks. The Executive Order also establishes permanent monthly reporting requirements for an urban water supplier's water usage, the amount of conservation achieved and any enforcement efforts. DWR is conducting a rulemaking process on validated water loss audit reporting that will run through 2017.

The Executive Order also directed five agencies to put together a framework document to address elements of the Executive Order. The final report, *Making Water Conservation a California Way of Life, Implementing Executive Order B-37-16,* was published in April 2017. The report calls for establishing interim water use targets by 2018, with final standards to be published by 2021, and increasing progress towards achieving final compliance in 2025. Under the proposed framework, overall water use targets will be established using residential water use budgets for indoor use, outdoor use and water loss, and utilities will also be required to implement CII performance-based measures. Water use targets will be modeled on the SB X7-7 Method 2 approach, which established budgets for indoor and outdoor water use, with refinements. Water suppliers that are not on track to meet interim or final standards-based targets may be provided with compliance assistance, and/or face enforcement actions from the Water Board.

3.5 FUTURE WATER DELIVERY PROJECTIONS

This section presents the projection methodology to estimate future water deliveries for the City's water service area, and presents delivery projections through 2040. The term 'water deliveries' is used rather than water demands, since projections estimate future water demands and include an allowance for water losses, or non-revenue water, so that they represent water delivered to the MPMW system.

3.5.1 Future Land Use

Land use planning information is used to develop estimates of where future development will occur and at what densities. This information is used along with unit water use factors to develop projections of future water demands for MPMW.

In 2016, the City completed a multi-year effort, called ConnectMenlo, which updated its General Plan Land Use and Circulation Elements and zoning for its Bayfront Area, which was designated as an M-2 zoning district (industrial land use) in the 1994 General Plan. ConnectMenlo established long-range planning for the Bayfront Area, which incorporates the business parks and industrial area between Highway 101 and the Bayfront Expressway.

The plan, which has a buildout planning horizon of 2040, incorporates land use changes in the Bayfront Area with development potential for up to 4,500 new multi-family residential units, 2.3 million square feet of new non-residential uses, 400 new hotel rooms and two transit centers. The Bayfront Area lies within MPMW boundaries, except for a small portion of the area, south of Highway 101, bounded by Marsh Road and the Dumbarton Rail line. Figure 3-2 shows the City's approved General Plan land use designations based on the ConnectMenlo planning update.

3.5.2 Future Population

The MPMW service area is largely built-out, with future growth trends principally due to redevelopment within the Bayfront Area. Table 3-8 summarizes projected population for the MPMW service area, based on General Plan buildout, and the additional population anticipated based on ConnectMenlo.

Table 3-8. Projected Population, MPMW Service Area[a]					
Development Plan	Year				
	2020	2025	2030	2035	2040
General Plan Buildout	18,224	18,321	18,419	18,516	18,614
ConnectMenlo	0	2,893	5,785	8,678	11,570
Total Population	**18,224**	**21,214**	**24,204**	**27,194**	**30,184**

(a) Source: MPMW 2015 Urban Water Management Plan. Projected population growth per the City's current General Plan from 2016 and onward was provided by the City's Planning Division and is documented in Appendix E of the UWMP.

3.5.3 Future Water Delivery Projections

As part of ConnectMenlo, the City prepared a Water Supply Evaluation (WSE) Study. The WES was incorporated in the Programmatic Environmental Impact Report that analyzed the effects of the zoning changes for the portion of the Bayfront Area to be served by MPMW. Table 3-9 summarizes the MPMW service area annual water delivery projections prepared for the WSE. Development of each of the delivery projections is described below.

Table 3-9. Projected Annual Water Deliveries					
Development Plan	Projected Water Deliveries (MG/year)				
	2020	2025	2030	2035	2040
General Plan Buildout[a]	1,310	1,286	1,265	1,251	1,240
ConnectMenlo[b]	0	86	172	257	343
Other Planned Projects[c]	31	31	31	31	31
Total Projected Water Demand	**1,341**	**1,403**	**1,468**	**1,539**	**1,614**
SFPUC Supply Assurance (Normal Year)[d]	1,630				
Supply Surplus[d]	**289**	**227**	**162**	**91**	**16**

Source: Water Supply Evaluation Study.

(a) Water delivery projections, as developed in the MPMW 2015 UWMP
(b) Project buildout by 2040. Phasing assumed to start in 2020.
(c) Other planned projects include the Facebook Campus Expansion and a new magnet high school.
(d) Refer to Table 4-1 for additional details regarding single or multiple dry years.

Water Deliveries for General Plan: Future water demands for the MPMW service area were projected by BAWSCA, as part of BAWSCA's 2014 Regional Demand and Conservation Projections project. Future water demands were projected using the Demand Management Decision Support System Model (DSS Model), which uses population and employment projections to estimate future water use. In 2015, MPMW updated the DSS model to account for revised population and employment projections prepared by the City's Planning Division. Water demands are projected to decrease from 2020 to 2040 due to different factors, including decreased water use in the industrial sector, and increased water use efficiency due to plumbing code changes and planned MPMW conservation efforts.

Water Demands for ConnectMenlo and Other Planned Projects: Demands for ConnectMenlo and Other Planned projects were developed as part of the WES for ConnectMenlo and the Water Supply Assessment for the Facebook Expansion project. Water use estimates were developed using methodologies to estimate indoor and outdoor water use, and account for City water use efficiency ordinances.

Table 3-10 summarizes future per capita water use, calculated by converting the projected annual use to average daily use and dividing by the projected population. As shown in the table, per capita water use is projected to be 202 gpcd in 2020, and decrease to 146 gpcd by 2040. MPMW's projected 2020 per capita use is slightly below its SBx7-7 2020 target water use of 202 gpcd. The decrease in per capita use after 2020 is due to several factors, including re-development of properties with less water intensive uses, increased conservation due to regulatory changes, such as new plumbing codes, and landscape ordinances that increase water use efficiency, and MPMW's planned expansion of its water conservation program.

Table 3-10. Projected Per Capita Water Use

Development Plan	Per Capita Water Use, gpcd				
	2020	2025	2030	2035	2040
Total Projected Water Demand (MG/year)	1,341	1,403	1,468	1,539	1,614
Projected Population	18,224	21,214	24,204	27,194	30,184
Per Capita Water Use (gpcd)	202	181	166	155	146

For water master planning, it is necessary to develop spatial estimates of future demands, so that they can be applied to the water distribution system model, for the analysis of future water distribution system needs. The system analysis evaluates 2040 conditions to assess infrastructure requirements with buildout of the General Plan. The ConnectMenlo environmental impact analysis included a spatial analysis of future land use development to analyze potential traffic impacts. This analysis used traffic analysis zone (TAZ) areas to evaluate land use changes associated with ConnectMenlo. For the WSMP, the TAZ areas were refined to create water analysis zone (WAZ) areas that included modifications to TAZ areas to conform with MPMW service area and pressure zone boundaries. Once WAZ areas were defined, MPMW prepared spatial projections of future water use by WAZ. Table 3-11 summarizes 2040 annual water use projections by pressure zone, based on the WAZ analysis. Figure 3-3 shows the WAZ areas and projected water use by WAZ.

Table 3-11. 2040 Annual Water Deliveries by Pressure Zone		
Pressure Zone	Water Analysis Zones used for Allocation of Future Demands	2040 Water Deliveries, MG/yr[a]
Lower	2025, 2026, 2027, 2069, 2070, 2116, 2118.1, 2259, 2264, 2268.1, 2352, 2357, 2433.1, 2451.1, 2451.2, 2452, 2471, 2601, 2602, 2619.1, 2870, 2891.2, 2905.1, 3008	938
High Pressure	2111.1, 2111.2, 2473, 2599, 2600, 2836, 2869, 2891.1	203
Upper	2007, 2031, 2074, 2274, 2347, 2348.1, 2556.1, 2582, 2622, 2624.2, 2625.1	473
	Total Water Deliveries	**1,614**

[a] WAZ shape file provided by MPMW. Future water deliveries include system losses.

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Last Revised: 08-01-16 W:\Clients\648\12-15-01\ENGR\Water Demand Evaluation\Chapter 3 Tables.xlsx

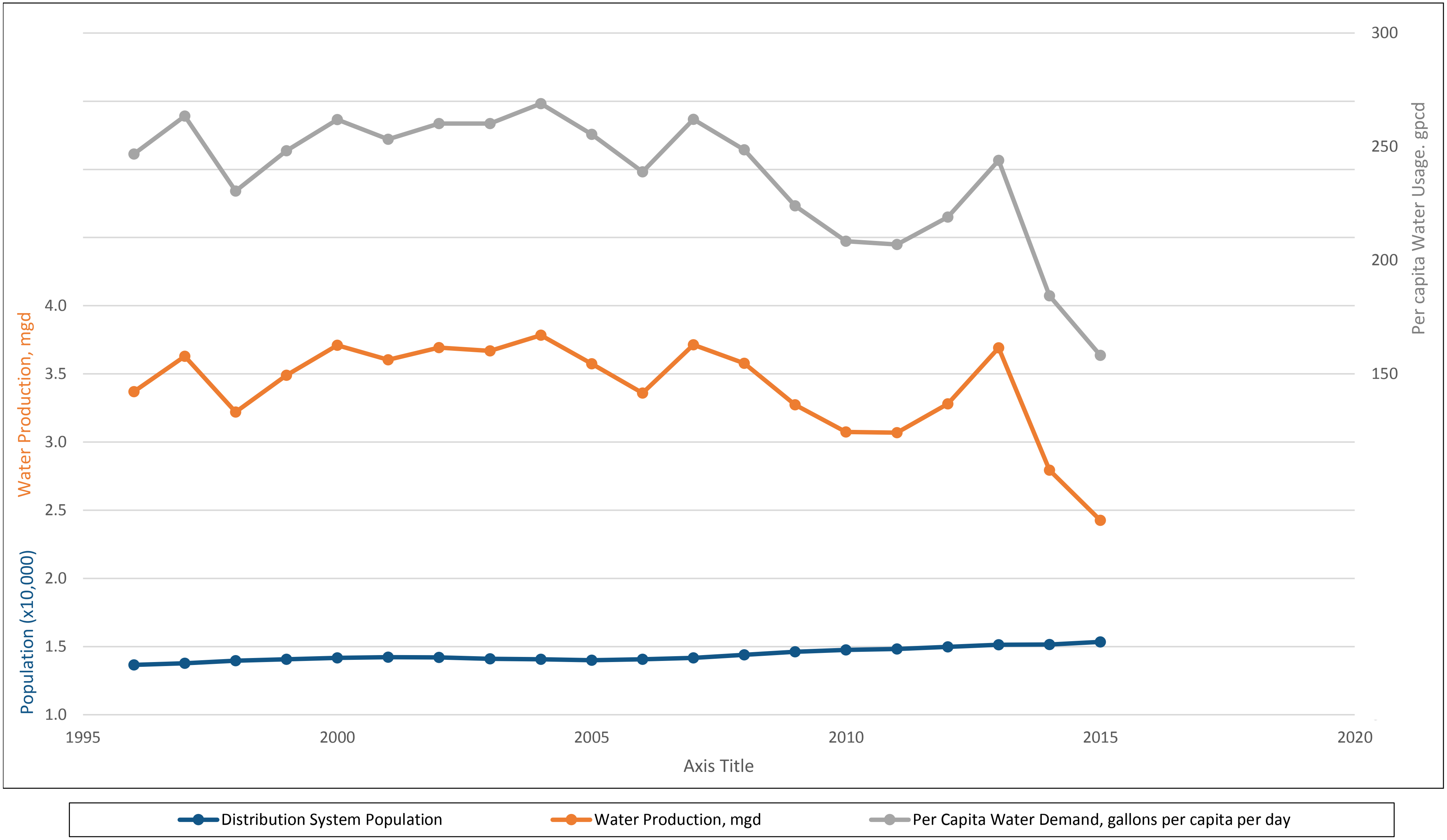

Figure 3-1

Historical Per Capita Water Use, Production, and Population

Menlo Park Municipal Water
Water System Master Plan

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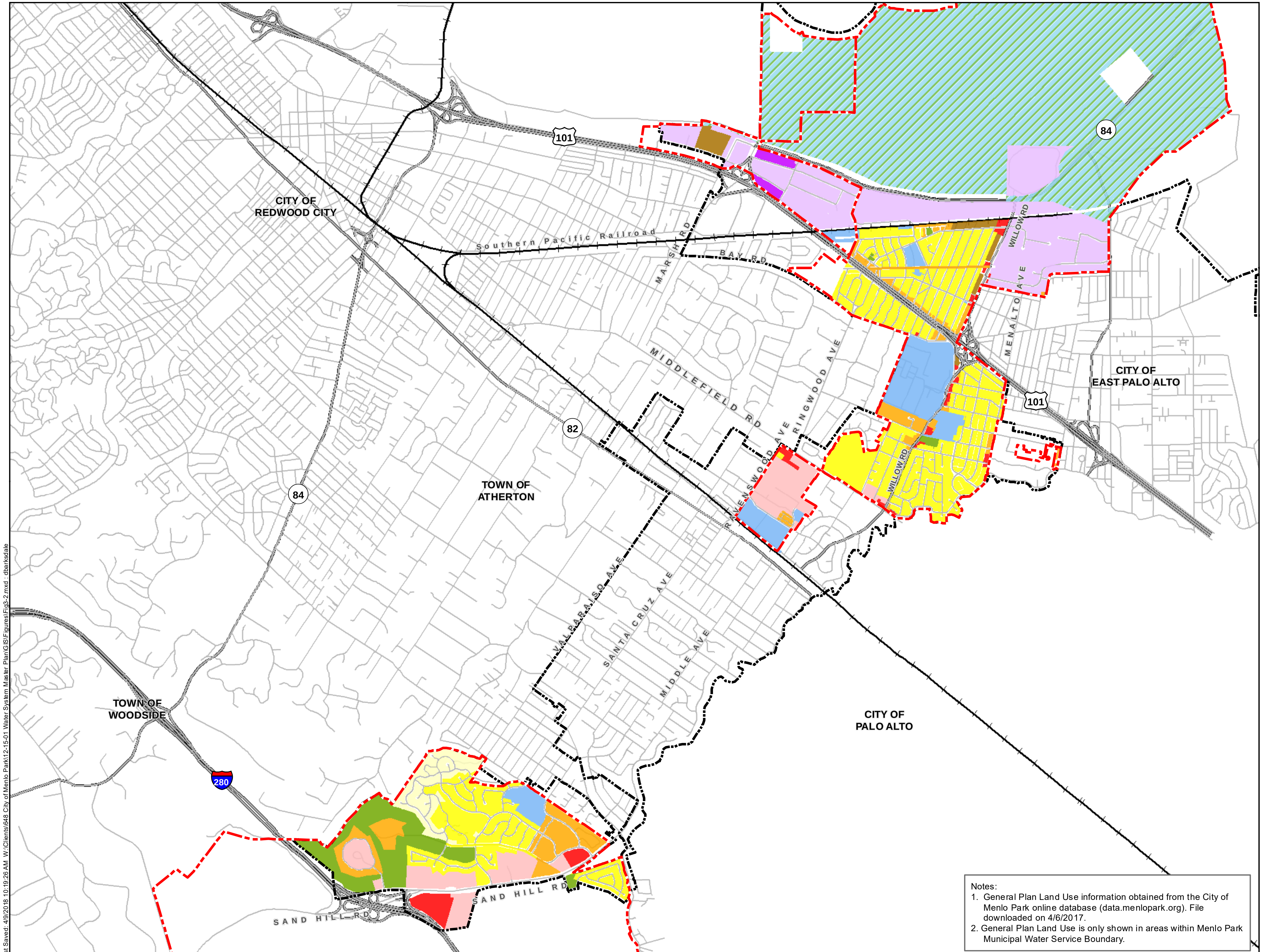

0 1,500 3,000
Scale in Feet

Water Service Boundary
City Limits

General Plan Land Use

- Residential Very Low Density
- Residential Low Density
- Residential Medium Density
- Residential High Density
- Limited Industry
- Commercial Business Park
- Commercial Offices
- Commercial Retail
- Non-Urban Marshes
- Parks & Recreation
- Public Facilities

Notes:
1. General Plan Land Use information obtained from the City of Menlo Park online database (data.menlopark.org). File downloaded on 4/6/2017.
2. General Plan Land Use is only shown in areas within Menlo Park Municipal Water Service Boundary.

CITY OF MENLO PARK
WEST YOST ASSOCIATES

Figure 3-2

General Plan Land Use

Menlo Park Municipal Water
Water System Master Plan

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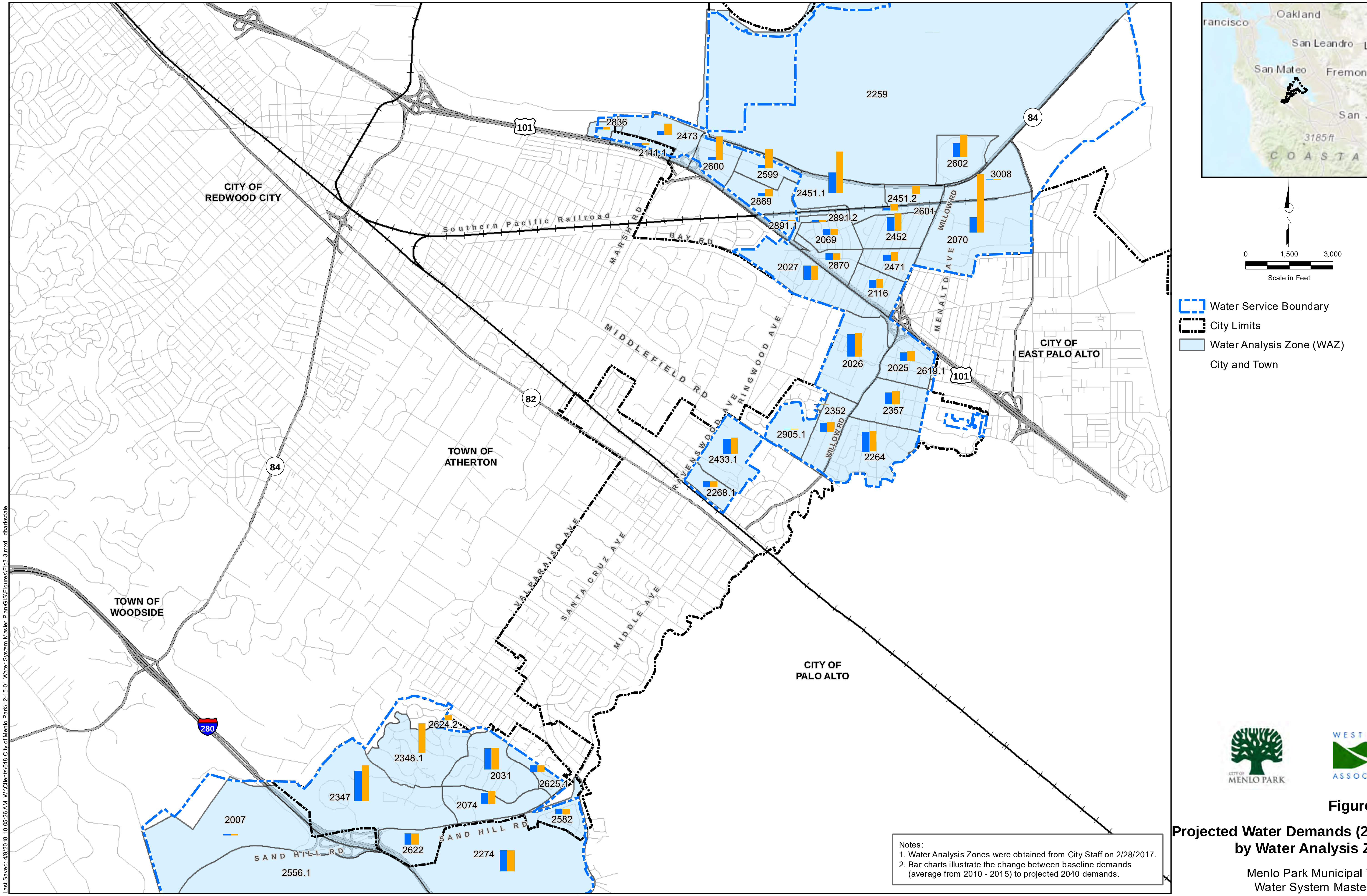

Figure 3-3

Projected Water Demands (2040) by Water Analysis Zone

Menlo Park Municipal Water
Water System Master Plan

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4.1 OVERVIEW

MPMW currently has one source of potable water supply - surface water purchased from SFPUC, which is used to meet all of MPMW's water needs. However, efforts are underway to develop groundwater wells to be used as an emergency backup supply. Other water sources, such as graywater and recycled water, are also being considered to offset potable water demand. This chapter includes a description of MPMW's existing surface water supply and potential other sources. For the development of recycled water as a non-potable water source, this chapter includes a description of potential sources of recycled water, the potential layout of facilities, as well as preliminary cost estimates for implementation.[1]

Specifically, this chapter evaluates the following:

- Graywater
- Recycled water from the cities of Redwood City and Palo Alto
- Recycled water from the West Bay Sanitary District (WBSD)

Supply evaluations were prepared in late 2015 and early 2016. Minor updates have been made where more recent information is available.

4.2 SFPUC SURFACE WATER

All of MPMW's water supply is purchased from the SFPUC. The SFPUC operates the City and County of San Francisco's RWS which delivers treated wholesale water to Alameda, Santa Clara, and San Mateo Counties. Approximately 85 percent of the RWS supply is routed through the Hetch Hetchy aqueducts from the Sierra Nevada. The Alameda and Peninsula watersheds produce about 15 percent of the total SFPUC water supply.

Due to constraints of hydrology, physical facilities, and the institutional parameters that allocate the water supply of the Tuolumne River, the RWS water supply cannot always meet demands. In order to increase reliability of the RWS, the SFPUC implemented the Water System Improvement Program (WSIP), approved October 31, 2008. The program was substantially completed in 2016. The SFPUC has also limited the volume of water that can be purchased from the RWS to 265 mgd until at least 2018. Collectively, member agencies and San Francisco can purchase no more than 265 mgd.

The current WSA between the City and County of San Francisco and Wholesale Customers was finalized in July 2009. SFPUC's wholesale customers received a "Supply Assurance" that provides 184 mgd on an annual average basis. However, if drought conditions, emergencies, malfunction or rehabilitation of the RWS lead to a water shortage, then SFPUC's wholesale customers are subject to reduction in water supply in the amount and duration required to resolve the shortage.

[1] Implementation costs include capital costs for the recycled water distribution system and annual energy costs to operate the recycled water system. They do not include costs to purchase the recycled water or to buy into an existing project.

Of the 184 mgd "Supply Assurance", MPMW's Individual Supply Guarantee is 4.465 mgd, approximately 1,630 acre-feet per year (AFY). Dry-year supply estimates developed for the 2015 UWMP are based on delivery estimates provided by BAWSCA and SFPUC and application of allocation processes laid out in the most recent water supply contract. Based on these allocations, MPMW would have an estimated supply of 3.51 mgd, or 1,277 MG/yr in a single dry year, and 3.04 mgd, or 1,109 MG/yr in the second and third years of a three-year drought. Year one of a multi-year drought would be the same allocation as a single dry year (EKI, 2015).

4.3 COMPARISON OF SUPPLY AND DEMAND

Table 4-1 provides a comparison of supply and demand, as presented in MPMW's 2015 UWMP. The table summarizes demand in five-year increments from 2020 through 2040. As the table shows, in normal hydrologic years, MPMW is anticipated to have sufficient supplies to meet demands. Starting in 2020, it is projected that in single-year or multi-year droughts, MPMW supply will be insufficient to meet demands. For single dry years, the shortfall is projected to be 21 percent by 2040. For multiple dry years, the shortfall is projected to be 31 percent by 2040. MPMW anticipates meeting shortfalls through implementation of its Water Shortage Contingency Plan, which specifies measures to temporarily reduce demand. Implementation of supply alternatives evaluated in this chapter would reduce potable water use, and thus reduce anticipated shortfalls.

Table 4-1 MPMW Comparison of Supply and Demand[(a)]

Demands and Supplies, MG/year	Year				
	2020	2025	2030	2035	2040
Total Projected Demand	1,341	1,403	1,468	1,539	1,614
Total Projected Supply – Normal Year	1630	1630	1630	1630	1630
Surplus or Deficit	289	227	162	91	16
Percent Shortfall	--	--	--	--	--
Total Projected Supply – Single Dry Year	**1,277**	**1,277**	**1,277**	**1,277**	**1,277**
Surplus or Deficit	(64)	(126)	(191)	(262)	(337)
Percent Shortfall	5%	9%	13%	17%	21%
Total Projected Supply – Multiple Year[(b)]	**1,109**	**1,109**	**1,109**	**1,109**	**1,109**
Surplus or Deficit	(232)	(294)	(359)	(430)	(505)
Percent Shortfall	17%	21%	24%	28%	31%

(a) Source: 2015 UWMP.

(b) Years shown are years two and three of a three-year drought. The first year is anticipated to have supply reductions the same as a single-year drought.

4.4 GROUNDWATER

Currently, MPMW does not use any groundwater supplies. MPMW has, however, undertaken a multi-year Emergency Water Supply Program to provide a local back-up source of potable and firefighting water supply in the Lower Zone, which serves the eastern portion of MPMW, in the event imported supply from the SFPUC is interrupted due to an earthquake or other emergency.

The proposed new Well 1 is the first of several projects envisioned under the Emergency Water Supply Program.

4.4.1 Basin Description

The MPMW service area overlies the Santa Clara Valley Groundwater Basin's San Mateo Plain Subbasin. The Santa Clara Subbasin, San Mateo Plain Subbasin, Niles Cone, and East Bay Plain make up the Santa Clara Valley Groundwater Basin. MPMW spans from the north end of the Santa Clara Valley Subbasin to the south end of the San Mateo Plain Subbasin. Neither the Santa Clara Valley Groundwater Basin nor any of the included subbasins are adjudicated. Located within the 45-square mile San Francisquito Creek Watershed, the MPMW service area contains both mountainous bedrock terrain and comparatively flat alluvial deposits. Coarse and fine grained alluvial deposits from the San Francisquito Creek can be found in the MPMW service area. There is a shallow aquifer and a deep aquifer that has an upper and a lower zone in the MPMW service area. Both aquifers lie beneath a laterally extensive confining layer. The shallow aquifer is unconfined while the deep aquifer is semi-confined. Pump tests and empirical transmissivity data show that it is feasible to develop a municipal supply from the groundwater subbasin. It is estimated that the groundwater subbasin can be as thick as 1,000 feet in some locations.

Groundwater in the Santa Clara Valley Groundwater Basin naturally flows toward the San Francisco Bay from the uplands in the southwest. Reverse groundwater gradients, from the San Francisco Bay toward the uplands, have been seen when pumping has exceeded the rate of recharge. The estimated annual recharge rate of the San Francisquito Creek watershed ranges from 4,000 to 8,000 AFY, 3.6 to 7.2 mgd. In the 2010 UWMP, it was also estimated that 1,100 AFY were being pumped each year from the groundwater basin (Winzler & Kelly, 2014).

As part of the implementation of the Sustainable Groundwater Management Act, the subbasin was ranked as a "very low priority" basin under the California Statewide Groundwater Elevation Monitoring basin prioritization process. As such, the basin is not subject to the requirements of SGMA (EKI, 2016).

4.4.2 Emergency Well Supply Program

The intent of the Emergency Water Supply Program is to construct 2 to 3 wells which could supply up to 3,000 gpm (4,480 AFY) of back-up water supply to meet the estimated water demand in the Lower Zone. The proposed new Well 1 located at 333 Burgess Drive, is the first of several projects envisioned under the Emergency Water Supply Program. The Well 1 was approved by the State Water Resources Control Board at the beginning of 2016 and construction is expected to be completed in 2017. Pumping tests conducted in 2017 at the Corporation Yard site indicated that the location may yield 1500 gpm.

Although the emergency supply volume is not large, the ability to supplement MPMW's existing supplies during times of emergency is of significant value to MPMW. In the event of earthquake damage to the SFPUC infrastructure, MPMW could be subject to reduced delivery of water for as long as 20-30 days (City, 2015). SFPUC WSIP goals are to provide basic service within 24 hours after a major earthquake and to restore facilities to meet average-day demand within 30 days. Basic service provided by SFPUC WSIP is average winter month water usage (SFPUC, 2015). The

MPMW emergency supply is especially critical to the 3,000 residential and business connections east of El Camino Real, in the Lower Zone of the MPMW service area, which does not contain any storage facilities or local water sources.

4.5 POTENTIAL GRAYWATER USE

Residential graywater is defined, in the California Plumbing Code, as water from showers, clothes washers, and other domestic drains other than the kitchen sink and toilets. MPMW is considering the implementation of a residential and/or commercial graywater program as a way to reduce potable water consumption within the MPMW service area as graywater has been found to offer potential for substantial potable water savings (National Academy of Sciences, 2016).

Graywater programs for certain types of commercial facilities that produce significant quantities of gray water, such as hotels, fitness facilities, and laundromats, may lead to significant potable water demand savings for those commercial customers. Most commercial facilities, however, like offices and restaurants, do not generate enough graywater to significantly offset the potable water demand from toilet flushing or irrigation (National Academy of Sciences, 2016).

Chapter 15 – Alternate Water Sources for Nonpotable Applications of the 2016 California Plumbing Code notes that water treatment is not required for systems that route the graywater directly to landscaping via subsurface or subsoil irrigation. However, to improve the end use versatility of graywater, on-site treatment of graywater is an option. Adding treatment to a gray water system makes the system inherently complex and is, therefore, typically only used in commercial applications—although it can also be permitted for residential applications. Treated graywater can be used for non-potable applications such as toilet and urinal flushing. All graywater treatment systems must meet NSF/ANSI Standard 350 if water quality standards have not been established by the jurisdiction.

The following text describes the state's current graywater regulations, County requirements, the feasibility of implementing a graywater program in the MPMW service area as a water conservation measure, a summary of graywater programs implemented by other utilities, potential graywater program costs, as well as recommendations for the City.

4.5.1 Current State Graywater Regulations

Graywater, both untreated and on-site treated, is regulated in California by the California Plumbing Code (2016 California Building Standards Code (Title 24, California Code of Regulations, Chapter 15 – Alternate Water Sources for Nonpotable Applications)), County and the Authority Having Jurisdiction (City's Building Official). A summary of the allowed uses of alternate water sources per the code are listed in Table 4-2.

Table 4-2. Summary of Allowed Uses of Alternate Water Sources per the California Plumbing Code

Alternate System Type	Description	Alternate Water Source	Use / Disposal	Treatment Required	Permit Required
Clothes Washer System (CPC 1502.1.1)	Clothes washer with discharge less than 250 gallons a day	Laundry water	Irrigation (above ground w/ at least 2" of mulch, rock, or soil as cover)	None	No
Simple System (CPC 1502.1.2)	Discharge less than 250 gallons a day	Laundry, bathroom sink, shower/bathtub	Irrigation (above ground w/ at least 2" of mulch, rock, or soil as cover)	None for subsurface or subsoil irrigation	Yes
Complex System (CPC 1502.1.3)	Discharge greater than 250 gallons a day	Laundry, bathroom sink, shower/bathtub	Irrigation (above ground w/ at least 2" of mulch, rock, or soil as cover)	None for subsurface or subsoil irrigation	Yes
Reclaimed (Recycled) Water System (CPC 1503.0)	Any size discharge that has been treated to recycled water standards	Treated municipal wastewater	Toilets, urinals, trap primers for floor drains and floor sinks, aboveground and subsurface irrigation, industrial or commercial cooling or air conditioning.	Disinfected tertiary treatment per Title 22 Water Recycling Criteria	Yes
On-Site Treated Nonpotable Gray Water System (CPC 1504.0)	Any size discharge that has been treated to water quality standards as specified in CPC 1504.0	Laundry, bathroom sink, shower/bathtub, swimming pool backwash operations, air conditioner condensate, rainwater, cooling tower blow-down water, foundation drainage, steam system condensate, fluid cooler discharge water, food steamer discharge water, combination over discharge water, industrial process water, and fire pump test water.	Toilets, urinals, trap primers for floor drains and floor sinks, above and belowground irrigation.	Disinfection for uses in which gray water is sprayed such as with toilet and urinal flushing Must meet NSF 350 or water quality requirements set by the public health Authority Having Jurisdiction	Yes

4.5.2 Current State of Untreated Graywater Regulations

In a number of cities, laundry to landscape programs have become popular (see section 4.4.6 for a description of the graywater programs being implemented by other utilities in California). Chapter 15 of the California Plumbing Code does not require the treatment of graywater that is discharged in a disposal field or used for subsurface or subsoil irrigation. Per the City's landscape ordinance, all newly constructed landscapes must use subsurface irrigation systems. Highlights of the sections of the 2016 California Plumbing Code, relevant to untreated graywater, are listed in Table 4-3.

However, one requirement is that the untreated graywater irrigation systems must have a discharge with at least two inches of soil, rock, or mulch cover which means sprinkler irrigation with untreated graywater is not allowed. The subsurface/subsoil requirement is a significant drawback to many customers who would like to utilize untreated graywater since a subsurface irrigation system requires costly irrigation system replacements for those who have an existing sprinkler irrigation system. However, per the City's landscape ordinance, all newly constructed landscapes must use subsurface irrigation systems. Another drawback to customers interested in installing an untreated graywater system is that the graywater system cannot completely replace a potable water irrigation system if one has a vegetable garden or other edible plants that touch the soil.

The requirements of the code likely require property owners to hire a professional to install the system (which makes these systems more expensive) and make the operation of the graywater system active, with annual inspection and cross-connection test requirements, rather than passive. So even for customers willing to install the expensive infrastructure for the graywater system, they must also be willing to actively manage the system throughout its lifetime. However, the expense of implementation and commitment to actively manage the system, is a decision for individual property owners—not the MPMW.

Table 4-3. Highlights of the Graywater Code for Untreated Graywater (aka Chapter 15, Alternate Water Sources for Nonpotable Applications, of the 2016 California Plumbing Code)[a]

- Graywater systems must be “designed by a person who demonstrates competency to design the alternate water source system as required by the Enforcing Agency”. (CPC 1501.2)
- Graywater systems may only be installed after obtaining a permit (with the exception of a clothes washer system meeting the requirements of Section 1502.1.1.). (CPC 1501.3)
- Annual visual system inspections and cross-connection tests are required. (CPC 1501.11 and 1504.12)
- Graywater systems must be designed with a diverter valve to allow the user to direct flow to the building sewer and either the irrigation field or disposal field. (CPC 1502.1(A) and 1502.2.2)
- Water used to wash infectious garments (like diapers), and water containing hazardous chemicals derived from activities such as cleaning car parts, washing greasy or oily rags, or disposing of waste solutions, must be diverted by the user to the building sewer. (CPC 1502.1(B) and 1502.1(F))
- Graywater may not be allowed to pool or runoff. (CPC 1502.1(C))
- Human contact with graywater or the soil irrigated by graywater shall be minimized and avoided. (CPC 1502.1(D))
- Operations and Maintenance Manuals are required to be provided by the system designer or installer to the owner. (CPC 1501.6 and 1502.1(H))
- A graywater system cannot be connected to a potable water system without an air gap or physical device which prevents backflow and prevents ponding or runoff of graywater. (CPC 1502.1(I) and 1502.3)
- Graywater should not be used to irrigate any crops intended for human consumption that come in contact with soil. (CPC 1502.2)
- Graywater systems should be able to handle peak flow rates either through a large enough disposal/irrigation field or a surge tank. (CPC 1502.2.1)
- Graywater must be used on the same site where the graywater is generated. (CPC 1502.4)
- Graywater systems should be designed to distribute the total amount of estimated graywater on a daily basis. (CPC 1502.8)
- Graywater systems will not be permitted where the absorption capacity of the soil is unable to accommodate the maximum discharge of the proposed graywater irrigation system. (CPC 1502.10.2)
- The only acceptable method of discharge is through subsurface/subsoil irrigation systems of disposal fields in which the discharge of the graywater is covered by at least two inches of material. (CPC 1502.1(D) and 1502.1(E))
- No permit is required for a clothes washer graywater system as long as no pump or surge tank is used. (CPC 1502.1.1)
- A plumbing, and potentially electrical, permit is required for a simple system that does not just involve graywater from a clothes washer. (CPC 1502.1.2(2))
- A plumbing, and potentially electrical, permit along with an environmental health review is required for a complex system. (CPC 1502.1.3(2))

[a] Please note that the code includes a number of “exceptions” that are not necessarily included in this list.

4.5.3 Current State of Treated Graywater Regulations

Most of the graywater regulations discussed above pertain to the use of untreated graywater, which is defined as untreated effluent water from showers, clothes washers, and other domestic drains other than the kitchen sink, dishwashers, and toilets that are used in a disposal field or for subsurface or subsoil irrigation. However, another option available for home and businesses is to treat their graywater. Treated graywater can be used for restricted indoor water use, such as toilet and urinal flushing, and above and below ground irrigation. Graywater treatment systems typically include: 1) screening in which insoluble material and residue is separated from the graywater and discharged to the sewer; 2) biological treatment; 3) filtration; and, 4) Ultraviolet (UV) and/or chlorine disinfection. The option of on-site treatment opens up opportunities for graywater use that were not previously available and offers a potentially significant reduction in potable water use. The treatment of graywater, however, only makes economic sense for new development due to the excessive cost of retrofitting the plumbing systems of existing structures to be dual-plumbed to accommodate a graywater treatment system. Treatment of graywater on a residential scale may also not make economic sense for the relatively small volume of reusable water generated. On the other hand, onsite graywater treatment systems for larger-scale water users, like commercial and industrial users, may be both cost-effective and save more significant quantities of potable water – thereby serving as an effective water conservation tool.

4.5.4 San Mateo County Graywater Requirements

County encourages both residential and commercial water users to consider utilizing graywater. The County does not require a permit for simple, residential laundry-to-landscape graywater systems that divert graywater from clothes washer systems to a sub-surface irrigation system. These types of systems must meet all requirements specified in Section 1602.1.1 of the Uniform Plumbing Code. All other residential graywater systems, such as those that utilize untreated water from bathroom sinks and bathtubs for subsurface irrigation and those that treat the graywater for use in surface drip and/or spray irrigation, require design plans to be submitted to the County's Environmental Health Division. The County also requires that all graywater collection, treatment, and irrigation equipment components meet NSF/ANSI Standard 350 which certifies the consistent production of water meeting water quality standards. The County may also require the installation of backflow protection devices at the water service to the residence.

For commercial applications of graywater, the County requires that all project plans be submitted to the County's Environmental Health Division for approval before installation and use. Although the treatment and use of graywater may be permitted, the onsite treatment of blackwater (i.e. water from toilets, kitchen sinks, dishwashers, and utility sinks) is currently prohibited by the County due to public health concerns and because blackwater requires advanced water treatment methods and extensive water quality monitoring before it can be safely reused.

4.5.5 Feasibility of Implementing Graywater Program in the MPMW as a Water Conservation Measure

A graywater program for MPMW customers could consist of many ways of encouraging the use of graywater, either through education, incentives, streamlined permitting, or ordinances for new construction. Based on initial research, it appears that the potential potable water savings that may result from residential, single-family home graywater programs is very small. Small existing residential lot sizes (and even smaller lot sizes for new construction) and the expense of retrofits both pose challenges for residential graywater implementation on any significant scale.

On the larger-scale, graywater systems may yield potable water savings for specific types of buildings and facilities (National Academy of Sciences, 2016). Graywater systems in large residential and commercial buildings like hotels, fitness facilities, and aquatic centers make sense and will actually yield potable water savings, as these facilities generate large amounts of graywater. Office and institutional facilities, however, do not generate adequate graywater to meet non-potable use needs while other facilities may produce large amounts of graywater but have minimal ways in which the non-potable water can be used (e.g. laundromat). MPMW will need to weigh potential program elements with the time and effort required to implement them. For example, relatively inexpensive program elements like providing links to web-based resources on graywater for the interested property owner could be easily implemented. And to maximize potable water demand reduction, the City may target its graywater outreach to large residential and businesses, such as hotels, that generate significant quantities of graywater and have many potential uses for graywater that can offset current potable water use.

4.5.6 Residential Graywater Programs Implemented by Other Utilities

Several utilities throughout California have graywater programs in which their potable water customers are encouraged to install graywater systems in order to reduce potable water demand. Most of the utilities with graywater programs tend to target residential graywater systems, probably due to the fact that single family laundry-to-landscape systems can be installed without a permit and because individual homeowners are ones who have requested the most guidance and support from the utilities.

City of Santa Barbara

The City of Santa Barbara has a residential graywater program and touts that the graywater section of the California Plumbing Code was “inspired in large part by the experience and suggestions from Santa Barbara residents.” The City provides a fact sheet, a “Guide to Permitting a Single-Family Graywater System”, a sample Laundry to Landscape plan, an instructional Laundry to Landscape video, and links to many other resources for those interested in pursuing a graywater system. The City also offers rebates for 50 percent of the cost of equipment needed for a laundry to landscape graywater system. The City provides links on its website to a countywide organization called the Sweetwater Collaborative which offers resources and conducts workshops on graywater, rain water harvesting, native landscaping, and similar topics. A link to the City’s webpage is included in the References at the end of this chapter.

The City’s graywater program is limited to Laundry to Landscape because this type of graywater use does not require a permit and, therefore, is much easier to implement. The cost of the City’s graywater program is very low, as the graywater program is just one of many tools offered to customers as part of the City's sustainable landscape program. The City estimates that materials for a typical Laundry to Landscape graywater systems cost between $400 and $600, and the City pays up to approximately $300 per typical graywater installation. These rebates are part of an existing landscape rebate program which is funded primarily through a grant the City has with the U.S. Bureau of Reclamation (USBR). Most of the City's landscape rebates have been funded through this USBR grant since 2009. Aside from the cost of rebates, the City hired a consultant in 2009 to establish the program and secure the USBR grant. Ongoing program costs are: minimal staff time (estimated at only 3 hours per month) and the cost of supporting periodic landscaping workshops offered free to the community. The City currently pays the Sweetwater Collaborative $600 per workshop that the organization performs on behalf of the City for the benefit of City water customers and local professional landscapers (Ward, 2015).

City of Berkeley

The City of Berkeley, though not a water provider, provides resources to its customers interested in residential graywater systems. Their website includes a guide for designing a clothes washer graywater system, guidelines to make the permitting process more clear, as well as a link to East Bay Municipal Utility District's (EBMUD's) website. EBMUD, the water purveyor in the City, offers rebates of up to $50 for graywater system 3-way diverter valves or $0.50 per 100 cubic feet (HCF) of calculated water saved (EBMUD, 2016). EBMUD also provides links to several graywater resources. The City has not tracked the effectiveness of graywater implementation and says that many of the existing graywater systems probably are not permitted. Although the City doesn't provide any staff resources for site visits, the City has worked cooperatively with the Berkeley Climate Action Group, which has sponsored the installation of a graywater system as well as made site visits to assist City residents contemplating the installation of graywater systems. A link to the City's webpage is included in the References at the end of this chapter (DeSnoo, 2015).

City of Santa Rosa

The City of Santa Rosa also has a residential graywater program in which it offers a $75 rebate per qualifying fixture that re-routes graywater for simple, single family residential graywater systems in which less than 250 gallons of graywater is used. The City also offers a $200 rebate for every 1,000 gallons of sustained reduction in monthly water consumption for larger, complex graywater systems. Approximately 50 of the $75 rebates have been issued while only one water user has taken advantage of the $200 rebate. The City, however, also offers a graywater system starter kit as an alternative to the $75 rebate. These kits cost the City about $90 each and include the three-way valve and other fixtures needed to install a simple graywater system. The City encourages residents to accept the kit instead of the rebate so that the City can be sure that the appropriate fixtures are used in the graywater system. The City has conducted about 250 home graywater systems inspections but the number of graywater systems that have been completed and are actively functioning within the City is not known. The City also provides a program brochure, periodic workshops, a graywater system checklist, sample owner's manual, and tenant and property owner's permission forms. The City typically hosts about four do-it-yourself graywater installation workshops a year that are free to the community, including City of Santa Rosa residents and residents from neighboring communities. Since 2010, the City has documented about

450 attendees at the workshops. A link to the City's webpage is included in the References at the end of this chapter (Gudino, 2016).

The driver for the City's graywater program in Santa Rosa, as in other communities with an active graywater program, was the water customers requesting information and support for installing a graywater program. In Santa Rosa, the interest was so great that by 2010 the City began its graywater rebate and informational program. This program has been successful in appeasing the City's water customers and encouraging water conservation and stewardship. The City also observes that their graywater program has been effective at increasing the number of graywater systems but the amount of associated potable water savings is unknown. Although the City has not tracked any associated potable water demand reduction it feels that this is a valuable program regardless of whether it results in any significant potable water demand reduction (Gudino, 2016).

City of San Francisco

In San Francisco, the SFPUC offers rebates up to $225 to help cover the cost of graywater project permits from the Department of Building Inspection. These rebates help promote graywater use for both residential and commercial water customers. For laundry-to-landscape systems, SFPUC offers residential customers a $125 discount off the purchase of a laundry-to-landscape graywater kit.

4.5.7 Potential Graywater Program Costs

As shown with the examples of Santa Barbara, Berkeley, and Santa Rosa, the actual cost of a residential graywater program to the MPMW is likely to be nominal as there are already many publicly available resources on graywater to which MPMW could point interested customers. The real cost of graywater systems is borne by individual customers and businesses. As mentioned previously, the 2 inch-covering requirement of a graywater system may make the system cost-prohibitive to some—especially those customers who already have sprinkler irrigation systems installed. Based on a 1999 study titled "Monitoring Graywater Use: Three Case Studies in California", conducted jointly by the City of Santa Barbara, EBMUD, DWR, and USBR, graywater systems are not cost-effective. With the cost of water increasing, the break-even point may be less than 20 years, but regardless they will take significant capital investment to install and the payback period is likely more than a decade.

Because graywater systems are not cost-effective to the individual customer, the rebates need to be substantial and/or the educational materials and coordination need to be significant enough for customers to be motivated to install a graywater system even though it may not make financial sense. Funds for rebates are often available through state and federal funding programs, with the dollar rebate amount determined by the managing agency. The City of Santa Barbara funds its rebate program through a USBR grant while the City of Santa Rosa funds its rebate program with ratepayer fees. The City of Santa Rosa estimates that its graywater program costs the City less than $5,000 per year for rebates. Although there is also staff time involved in administering a graywater program, most cities and utilities already have a conservation program and the graywater program is a natural extension of existing conservation programs. Therefore, new staff is rarely required to administer a simple graywater program as the staff time is absorbed by existing conservation program staff. Graywater installations do not require annual inspections or reporting to meet permit conditions, so staff involvement is generally limited to responding to customer inquiries. In short, if the MPMW determines that there is enough interest in graywater system installations by its customers and sees graywater as a worthwhile puzzle piece in the pursuit of potable consumption reduction, program costs should not present a roadblock.

4.5.8 Findings and Recommendations

Although residential graywater has been found to offer potential for substantial potable water savings (up to 21 gpcd for the typical household), graywater used for toilet flushing has demonstrated potable water demand savings of 11 gpcd while the potential potable water demand savings associated with graywater irrigation has not been clearly documented in case studies. Researchers have found mixed results for the potable water savings associated with individual residential graywater irrigation programs. Potable water use may increase with the installation of household laundry-to-landscape graywater programs as customer water use behavior may change with the installation of a graywater irrigation system. Increased domestic water usage patterns were observed after graywater landscape irrigation systems were installed in several residences in both the Cities of San Francisco and Long Beach (National Academy of Sciences, 2016). While these findings are based on limited data, they indicate that a residential graywater use program targeted at landscaping may not be effective in achieving water conservation goals. Further monitoring would be required to assess their effectiveness as a water conservation measure.

Although single family home graywater programs may not result in immediate potable water demand reduction, in the long-run, these programs may cause water customers to be more aware of their plant's water requirements and more aware of water conservation in general which, over time, will result in more water-wise landscaping and other water-saving measures around their house. As a staff member from Santa Barbara noted, "a graywater system offers a gateway to sustainable landscaping." While this may be true for the customers that insist on maintaining water-intensive landscapes, conservation programs, such as MPMW's "Lawn Be Gone" program, may be more effective at improving water-wise landscaping and achieving more permanent potable demand reduction. The "Lawn Be Gone" program involves a rebate of $2 per square foot of lawn converted into water efficient landscape. The National Academy of Sciences Committee on the Beneficial Uses of Graywater and Stormwater stated that "significantly reducing irrigation demand, for example through the use of water-efficient landscaping, would provide much larger reductions in water demand than stormwater or graywater use in arid regions" and that, in fact, "graywater and stormwater may help facilitate the continued use of landscaping that is inappropriate for local climate conditions and not sustainable in the long term" (National Academy of Sciences, 2016).

Although conservation programs may be more effective, a conservation program in tandem with a graywater program may be the best approach for MPMW because graywater programs offer a tangible way for individual customers to experience the reuse of a water resource that would otherwise be discharged to the sewer, thereby paving the way for more recycled water use in the future. Similar to the recent surge in recycled water residential fill stations in the Bay Area, though the potable water demand savings may be negligible, and the program is not cost-effective, the community members are enthusiastic about this program and the water agency receives a lot of positive public relations from this program. Fill stations, like graywater programs, are relatively low in cost to implement and help the community become more aware of the value of water and allow the customer to participate in helping the environment and conserve water (even if negligible to the water agency)—an outreach and public education benefit. It is suggested that MPMW encourage all options for the community to participate in water conservation, including gray water. Furthermore, by promoting graywater and having the public develop a level of comfort with graywater, the public is likely to be more accepting of recycled water use, including indirect and direct potable reuse in the future.

MPMW may also want to promote graywater use in commercial settings through requiring, in City code, dual-plumbing in new commercial construction to accommodate potential future graywater or recycled water use. MPMW could also focus education efforts on developers constructing new commercial facilities likely to produce a substantial quantity of graywater such as fitness centers, hotels, aquatic centers, and laundromats.

If the investment is minimal (i.e. like Santa Rosa's costs—in the range of $5,000 per year in direct costs plus nominal staff time) to the MPMW, and there is sufficient interest in graywater amongst water customers, it may be prudent to develop a graywater program and include dual-plumbing requirements for new commercial facilities in the City code, to encourage water conservation, reuse, and environmental stewardship while at the same time maintaining the City's progressive image through promoting this "green" alternative.

Some inexpensive ways to begin a graywater program include providing fact sheets, guides, instructional videos, as well as links to other resources on the City's websites using existing materials created by other cities and/or organizations such as the Sweetwater Collective in Santa Barbara and the Grey Water Action Network in the Bay Area. Furthermore, the City could also include on its website a calendar of events hosted by the Grey Water Action Network and related organizations. As has been successful in other cities, the City should roll this graywater program into an existing water conservation or sustainability program to maintain efficiency with staff resources.

Aside from these simple and inexpensive informational residential program investments, and potential City code changes for commercial dual plumbing, it is not recommended that MPMW expend additional resources on this program if the primary purpose of the program is reduced potable water consumption, since the yield in potable water savings is not expected to be substantial if at all. Instead, it is recommended that MPMW put its resources towards conservation programs, such as the Lawn-be-Gone program, and other supply alternatives, such as a recycled water program, and only fund a graywater program as a secondary measure, to reduce potable water demand. However, there may be many long-term public education and public relations benefits of implementing a gray water program.

4.6 RECYCLED WATER USE

MPMW currently does not use any recycled water. However, there are many local benefits of having a recycled water supply source – including having an alternative source of water when there are potable water shortfalls during periods of persistent drought conditions, minimizing potable water demands as growth within MPMW continues to occur, and providing public relations benefit for MPMW for promoting and developing an environmentally responsible project.

4.6.1 Potential Sources of Recycled Water

One major reason that the MPMW has not considered a recycled water program to-date is that the City does not own or operate any wastewater treatment facility and, doesn't convey its own wastewater. Therefore, any recycled water program would require coordination and various agreements with one or more agencies. The specific agencies with which the City could coordinate a recycled water program include the City of Redwood City, the City of Palo Alto, and the WBSD.

4.6.1.1 City of Redwood City

The City of Redwood City (Redwood City) has indicated it has ample recycled water supply available for purchase by MPMW. Redwood City's wastewater is conveyed to the sub-regional wastewater treatment plant, Silicon Valley Clean Water (SVCW), located at the eastern end of the Redwood Shores peninsula in Redwood City. SVCW is a joint powers authority (JPA) comprised of four member agencies: Redwood City, Belmont, San Carlos, and the WBSD, which serves Menlo Park, Atherton, Portola Valley, and portions of East Palo Alto. The SVCW treatment plant has a permitted operating capacity of 29 mgd average dry weather flow (ADWF) and a peak wet weather flow (PWWF) design capacity of 71 mgd. Pursuant to the JPA, Redwood City has maximum capacity rights of 13.775 ADWF and 30.5 PWWF (City of Redwood City Public Works Services Department, 2011). Redwood City's wastewater allocation for the SVCW facility is shown in Table 4-4 which was reproduced from Redwood City's 2010 UWMP.

Table 4-4. ADWF Capacity Allocation for SVCW, mgd[a]

	Belmont	San Carlos	West Bay Sanitary District	Redwood City	Total
Capacity Allocated	2.779	4.471	7.975	13.775	29.0

(a) Table reproduced from Redwood City's 2010 Urban Water Management Plan.

Through the use of filtration, wastewater at SVCW is treated to advanced secondary standards. A portion of the secondary effluent is diverted and treated to disinfected tertiary recycled water criteria (Title 22 of the California Code of Regulations) established by the California Division of Drinking Water. As shown in Figure 4-1, the recycled water is delivered into storage tanks (located at the SVCW plant) that are owned and operated by Redwood City staff for use in Redwood City's recycled water distribution system. Table 4-5 summarizes the 2010 actual and 2015 through 2030 projected amounts, from the Redwood City 2010 UWMP, of wastewater treated at the SVCW plant and disposed either via the San Francisco Bay outfall or for recycled water use.

Table 4-5. SVCW Wastewater Collection and Treatment, AFY[a]					
Source	2010	2015	2020	2025	2030
Wastewater collected in Redwood City	9,420	9,723	10,014	10,283	10,540
Wastewater collected in SVCW service area	19,714	20,498	21,282	22,066	22,626
Quantity of wastewater meeting “unrestricted use” for Redwood City recycled water customers	490	987	1,280	1,453	1,611
Quantity of wastewater meeting “unrestricted use” recycled water criteria, for use in SVCW landscape impoundment[b]	92	92	92	92	92

(a) Table reproduced from Redwood City’s 2010 Urban Water Management Plan.
(b) SVCW uses recycled water to fill its onsite landscape impoundment. This is listed as a separate line item to avoid confusion with Redwood City recycled water customers who use recycled water as potable water offset.

According to Redwood City’s 2010 UWMP, member agencies of SVCW are each entitled to a share of SVCW’s effluent, proportional to their capacity allocation, and may eventually wish to exercise their entitlement. Although SVCW owns and operates the primary and secondary treatment facilities, Redwood City owns the disinfected tertiary facilities and has the capacity to serve the SCVC member agencies, along with non-SVCW member agencies like MPMW, with high quality recycled water. Redwood City owns, and the SCVC operates, the tertiary treatment facilities while Redwood City both owns and operates the recycled water storage and distribution system. Currently, Redwood City’s distribution system extends to and serves customers east of Highway 101 in Redwood Shores, the Greater Bayfront Area, and the Seaport Area.

Table 4-6 summarizes the 2010 and projected amounts for 2015 through 2030, from the 2010 UWMP, of wastewater treated to advanced secondary and tertiary levels at the SVCW plant. These values are based on what Redwood City projects that its own customers could utilize and do not account for the sale of recycled water to other agencies.

Table 4-6. Wastewater Disposal and Reuse, AFY[a]						
	Treatment Level	2010	2015	2020	2025	2030
Wastewater discharged through outfall	Advanced secondary	19,132	19,420	19,910	20,521	20,923
Wastewater treated and used for Redwood City recycled water customers	Disinfected tertiary	490	987	1,280	1,453	1,611
Wastewater treated and used for SVCW landscape impoundment[b]	Disinfected tertiary	92	92	92	92	92

(a) Table reproduced from Redwood City’s 2010 Urban Water Management Plan.
(b) SVCW uses recycled water to fill its onsite landscape impoundment. This is listed as a separate line item to avoid confusion with Redwood City recycled water customers who use recycled water as potable water offset.

Design and construction of the Redwood City Recycled Water Project was initiated in 2004, and included permanent recycled water treatment and storage facilities at SVCW, a recycled water distribution system, and on-site customer retrofit facilities. Redwood City's treatment facilities at SVCW can produce up to 9,000 gpm (13.0 mgd) (peak hourly flow) of disinfected tertiary recycled water, reservoirs at SVCW provide 4.36 million gallons of storage, and the pump station at SVCW can deliver up to 13,100 gpm (18.86 mgd) of recycled water to the transmission system (City of Redwood City Public Works Services Department, 2011). Therefore, ample recycled water could be made available to interested agencies.

Redwood City's environmental documentation for the recycled water project includes a system capable of producing and delivering up to 3,238 AFY (2.89 mgd average daily flow). Therefore, the recycled water facilities have been designed with the intention of eventually delivering up to 3,238 AFY. The facilities installed to date were constructed to supply Phase 1 of the project, up to 2,000 AFY (1.79 mgd average daily flow), while providing the flexibility to cost-effectively deliver up to an annual delivery amount of 3,238 AFY if needed. Installed treatment, pumping, and pipeline facilities have been sized for project build-out. However, additional storage facilities and booster pump stations would be required to reach full intended project capacity. Buildout of Phase 2 would include peak hour flows of 8,800 gpm (12.7 mgd), leaving additional capacity within the existing system, up to 8,600 gpm (12.4 mgd), that could be made available to others if the treatment and pump station were expanded (City of Redwood City Public Works Services Department, 2011). Table 4-7 summarizes facilities capacities by phase.

Table 4-7. Recycled Water Project Facilities and Capacities by Phase

Recycled Water Facility	Phase 1 Capacity (already constructed)	Anticipated Phase 2 Capacity	Anticipated Buildout Capacity
Tertiary Treatment Facility	Up to 2,000 AFY (1.79 mgd) average daily flow; Up to 9,000 gpm (13.0 mgd) peak hourly flow	Up to 3,238 AFY (2.89 mgd) average daily flow; Up to 9,000 gpm (13.0 mgd) peak hourly flow	Up to 3,238 AFY (2.89 mgd); Up to 9,000 gpm (13.0 mgd) peak hourly flow
Pumping Facilities at SVCV	13,100 gpm (18.86 mgd)	13,100 gpm (18.86 mgd)	13,100 gpm (18.86 mgd)
Transmission Pipelines	3,238 AFY (2.89 mgd)	3,238 AFY (2.89 mgd)	3,238 AFY (2.89 mgd)
Storage	4.36 million gallons	4.36 million gallons	6.54 million gallons
Booster Pump Stations	0	TBD	TBD

As the Redwood City recycled water project expands to meet demands in the Phase 2 project area, the City will continue to seek new opportunities to increase recycled water use. The 3,238 AFY of projected demand associated with the recycled water project approved in 2003 was used to plan and design the facilities. However, it may be possible that the existing facilities can produce more recycled water depending on how certain facility elements are operated, modified and/or expanded. Pumping and pipeline facilities were sized to deliver peak hour demands for all the customers associated with the 3,238 AFY annual demand. Some additional capacity was provided in the major transmission system by slightly increasing pipeline diameters in the major pipelines located between SVCW and Redwood City's Seaport area. The additional capacity was approved by City Council to build flexibility into the system should the system evolve to serve additional customers in the future. However, no specific additional demand target or system capacity was established for the conveyance system upsizing (Du, 2015).

Redwood City's distribution system portion of the recycled water project includes two phases. Phase 1 has already been constructed and includes pipelines and customers east of Highway 101 in Redwood Shores, the Greater Bayfront Area, and the Seaport Area (shown as existing facilities in Figure 4-1). Phase 2 will eventually include pipelines and pumping facilities to serve customers west of Highway 101. The 24-inch diameter recycled water main backbone pipeline distribution system, storage, and pump stations for Phase 1 are complete. Phase 1 includes 14.75 miles of pipelines. Smaller branches off of the main line will continue to be added as needed. A portion of the 24-inch diameter backbone of the Phase 2 recycled water distribution system will be designed in 2016 with the goal for part of the construction to be complete by the end of 2017 in order to supply recycled water to new buildings at the Stanford Medical Center, Redwood City Campus by 2018. Figure 4-1 shows the layout of Redwood City's current plans for the major Phase 2 recycled water system facilities.

If MPMW is interested in receiving recycled water from Redwood City, a 12-inch to 14-inch diameter branch pipeline could be constructed to Menlo Park from the 24-inch diameter backbone that would run parallel to Highway 84 or from the 12-inch to 14-inch diameter line serving Stanford Medical Center. Another potential option is for a 12-inch to 14-inch diameter pipeline to be constructed from the existing 24-inch pipe just north of Highway 101 near Bair Island Road and run along East Bayshore Road to Haven Avenue into Menlo Park. Actual pipeline sizes, tie-ins, and alignments would need to be confirmed by computer model analyses based on planned demands, supply and system operation. This Redwood City recycled water supply pipe size upgrade would be in addition to new MPMW-owned recycled water facilities (pipelines, pump stations, and tanks) that would need to be built by, and in, Menlo Park to receive, store, and distribute recycled water to MPMW customers. Besides facility investments, equally important issues for MPMW to consider are recycled water operation licensing, permitting, operation, training, water quality control and reporting. If MPMW is interested in pursuing a recycled water program with water purchased from Redwood City, it is recommended that MPMW begin discussions with Redwood City immediately before Phase 2 backbone pipeline design plans are finalized.

In its 2010 UWMP, Redwood City stated that it didn't have current plans for exporting its recycled water beyond its own service area, however the City may consider exporting recycled water to neighboring communities in the near future. The 2010 UWMP further stated that exporting recycled water would provide a regional benefit by reducing regional potable water use and optimizing the recycled water infrastructure already in place (City of Redwood City Public Works Services Department, 2011). Based on this information, the fact that the treatment capacity was sized to accommodate expansion into the service areas of the member agencies, and informal discussions with Redwood City staff, Redwood City has indicated interest in discussing what would be involved in developing a recycled water purchase agreement with MPMW.

The actual cost to Redwood City for producing and distributing water, averaged over the past three years, including its debt service for capital expenses, is $16.50 per HCF of water produced, or $7,200 per acre-foot. The debt normalized wholesale cost to Redwood City's existing recycled water customers is about $6/HCF ($2,600/AF) which is the actual cost to Redwood City to produce the recycled water including the debt service associated with the amount of recycled water currently being delivered. This normalized wholesale cost would be less as more recycled water users are added to the system (Chapel, 2016). Potential costs of the recycled water to MPMW would likely include this unit cost for the recycled water in addition to a capacity charge/buy-in fee to compensate Redwood City for the investment it has made in the recycled water treatment and distribution system. It is not yet clear what an appropriate capacity charge for the recycled water would be and would likely vary depending on the quantity of water ultimately delivered to MPMW and the extent of other expansions of Redwood City's recycled water program.

4.6.1.2 City of Palo Alto

The City of Palo Alto (Palo Alto) has a long history of producing and delivering recycled water within its jurisdiction. Its recycled water program began in the early 1980s, with the delivery of recycled water to Shoreline Golf Links, and was later expanded to include the Palo Alto Municipal Golf Course, Greer Park, and the Emily Renzel Marsh. In 1992, Palo Alto completed a Water Reclamation Master Plan for the Regional Water Quality Control Plant (RWQCP), a wastewater treatment plant that serves East Palo Alto Sanitary District, Los Altos, Los Altos Hills, Mountain View, Palo Alto, and Stanford University. This 1992 Water Reclamation Master Plan laid the groundwork for each of the City's recycled water phases of implementation including, and now called, Phase 2 which began delivering recycled water in 2009 to the City of Mountain View and Phase 3 which will deliver recycled water to south Palo Alto and is slated for construction in 2018. Future phases in the 1992 Plan include delivery of recycled water to East Palo Alto among other areas to the west and south of the RWQCP (Brown and Caldwell, 1992).

In 2015, the City prepared an Environmental Impact Report for the Phase 3 project, called the Palo Alto Recycled Water Project. The project would deliver recycled water from the RWQCP to parks and commercial customers in South Palo Alto and near the Stanford Research Park.

The City of Palo Alto owns and operates the RWQCP. Approximately 220,000 people live in the RWQCP service area. The RWQCP has an ADWF design capacity of 39 mgd with full tertiary treatment, and a PWWF capacity of 80 mgd with full secondary treatment. Current average flows are approximately 20 mgd. The RWQCP's secondary treatment includes fixed film reactors, conventional activated sludge, clarification and filtration and the tertiary treatment involves filtration through a sand and coal filter and UV disinfection. Currently, the plant can produce approximately 4.5 mgd of recycled water that meets the Title 22 unrestricted use standard. In September 2010, the RWQCP completed the installation of a new ultraviolet disinfection facility which will allow for a gradual increase in the amount of recycled water that meets the Title 22 unrestricted use standard. The remaining treated wastewater meets the restricted use standard and can also be recycled. (City of Palo Alto, 2011 and North, 2016).

Even with the Phase 1 and Phase 2 recycled water projects online, the City of Palo Alto produces more recycled water than it can use and the City is seeking ways in which this recycled water can be put to beneficial use. The Phase 1 and 2 projects combined only use about 1 mgd of the recycled water produced at the RWQCP. Even after Phase 3 is complete, the plant will have more recycled water treatment capacity than necessary for existing recycled water projects. Therefore, the City of Palo Alto is not planning any treatment facility upgrades to increase recycled water capacity at this time. However, the City is contemplating upgrading the RWQCP to improve recycled water quality, as it is currently conducting preliminary design for a 1 mgd Advanced Water Purification Facility (Engelage, 2017). As a result of high total dissolved solids (TDS) levels (800 – 1,000 mg/L) that the City has been unsuccessful at controlling through source control, the City is considering adding a reverse osmosis treatment step for a portion of the recycled water treated to unrestricted use standards. This low TDS water would be blended with the higher TDS water currently produced to achieve the 600 mg/L salinity-level-goal for recycled water set by Palo Alto and its partner agencies (Carollo, 2012). Reducing the TDS of the unrestricted use recycled water is important for irrigation customers who want to use the recycled water for irrigation of salt sensitive plants, such as redwood trees.

As of 2010, about 233 AFY of unrestricted use recycled water produced by the RWQCP was used within Palo Alto for irrigation of City-owned facilities such as the Greer Park and the Palo Alto Municipal Golf Course as well as water for the City's Duck Pond. Unrestricted use recycled water is also used at the Palo Alto Municipal Service Center for a variety of applications such as street sweepers, dust control at construction sites, vehicle washing, and for irrigating road median strips. The quantities of this use vary, but can be up to 5,000 gallons per day. 1.0 to 1.5 mgd of restricted use recycled water is used for enhancements at the 14-acre freshwater Emily Renzel Marsh (City of Palo Alto, 2011).

The Phase 2 pipeline that has served Shoreline Park and other customers in Mountain View since 2009, received approximately 391 AFY of recycled water in 2010 and is projected to receive approximately 1,500 AFY at peak production. The Phase 3 project will initially deliver approximately 900 AFY of recycled water to parks and commercial customers in South Palo Alto and near the Stanford Research Park. Since December 2016, the City has been working on the Northwest County Recycled Water Strategic Plan in collaboration with the Santa Clara Valley Water District. This plan is scheduled for completion in 2020 and is intended to replace the 1992 Water Reclamation Master Plan. The terminology of "Phase 3" and "Phase 4", as well as the current scope of Phase 3 and concept of Phase 4 will likely change during the Northwest County Recycled Water Strategic Plan process (Engelage, 2017).

Currently, the City of Palo Alto does not charge for its recycled water because the water is only delivered to City facilities and the City of Mountain View – each of whom have already contributed to the cost of the RWQCP and have paid for their own recycled water pipelines and related facilities. Because the City doesn't charge for the recycled water it currently delivers, it is unknown exactly how much it costs the City to produce and distribute the recycled water (North, 2015). In the City's 2008 Recycled Water Facility Plan, the annualized cost of the Phase 3 project, including capital and Operation and Maintenance (O&M) costs, was estimated to cost approximately $2,700/AF (RMC, 2008).

The City of Palo Alto and its wastewater collection partners (the East Palo Alto Sanitary District, City of Los Altos, Town of Los Altos Hills, City of Mountain View, and Stanford University) are interested in expanding recycled water use – including areas outside of the RWQCP collection system boundaries. Therefore, if MPMW is interested in receiving recycled water from Palo Alto, a pipeline could be constructed to Menlo Park from the distribution line planned to run parallel to Highway 101 to East Palo Alto in a future phase. If MPMW is interested in pursuing a recycled water program with water purchased from Palo Alto, it is recommended that MPMW begin discussions with Palo Alto in early 2018 when the City of Palo Alto is expected to have completed its groundwater investigations as part of the Northwest County Recycled Water Strategic Plan and be ready to begin discussions with outside agencies, such as MPMW, regarding participation in future recycled water phases (Engelage, 2017).

The costs to Palo Alto for treating and distributing recycled water for Menlo Park should be determined in Palo Alto's recycled water business assessment that is currently in process. Without actual numbers, the range of potential costs for the recycled water to Menlo Park from Palo Alto can only be speculated. The cost is likely to be between $2,100 and $3,100 per acre-foot based on 20 percent below Redwood City's current cost for the low end of the range and 20 percent above Redwood City's current cost for the high end of the range. Palo Alto would likely charge MPMWD a unit cost in this range for the recycled water in addition to a capacity charge/buy-in fee to compensate Palo Alto for the investment it made into the recycled water treatment and distribution system. It is not yet clear what an appropriate capacity charge for the recycled water would be and would likely vary depending on the quantity of water ultimately delivered to MPMWD and the extent of other expansions of Palo Alto's recycled water program.

4.6.1.3 West Bay Sanitary District

WBSD provides wastewater collection and conveyance services to the City, as well as Atherton and Portola Valley, areas of East Palo Alto, Woodside, and unincorporated San Mateo and Santa Clara counties. The District uses the Menlo Park Pump Station and force main to SVCW in Redwood City to convey wastewater for treatment and discharge into San Francisco Bay.

In September 2015, WBSD completed a Facilities Plan for a decentralized recycled water treatment facility at the 170-acre Sharon Heights Golf and Country Club (G&CC) to supply the Sharon Heights area with recycled water for irrigation and nearby industrial users. WBSD completed the California Environmental Quality Act (CEQA) process for this project and filed a mitigated negative declaration in October 2015. The recycled water project includes a 0.5 mgd satellite wastewater treatment plant, an influent pump station and pipeline, a solids discharge pipeline back to the sewer, and a recycled water pump station and delivery pipelines within the Sharon Heights G&CC and along roadway rights-of-way. The recycled water project would supply up to 236 AFY of recycled water in Phase I – up to 152 AFY to Sharon Heights G&CC and up to 84 AFY to the Stanford Linear Accelerator Center (SLAC) National Accelerator Laboratory. Phase II of the project would supply an additional 45 AFY. All prospective recycled water customers in this project are located within the MPMW service area and are currently receiving potable water from MPMW. WBSD would serve as the recycled water purveyor for the recycled water distributed to these large customers –although an agreement between MPMW and WBSD would be necessary to confirm who would act as the recycled water purveyor. The recycled water produced by this project would provide Sharon Heights G&CC and SLAC with new sources of irrigation and cooling tower water, thus offsetting potable water usage and reducing the amount of SFPUC water MPMW needs to serve these customers (RMC, 2015). The project has secured funding through the Clean Water State Revolving Fund loan program, and has been awarded to a design-build contractor for construction of Phase 1, with estimated completion of construction in 2018 (West Bay Sanitary District, 2017).

4.6.2 Potential Uses for Recycled Water

Disinfected tertiary recycled water from Redwood City, Palo Alto or WBSD could be used for a number of different uses including but not limited to: irrigation of parks, school yards, residential landscaping, and golf courses; recreational impoundments; industrial or commercial cooling or air conditioning; toilet flushing; industrial processes; firefighting; decorative fountains; commercial laundries; commercial car washes; cleaning outdoor work areas; soil compaction; dust control; and flushing of sanitary sewers. The list of potential uses is extensive and a more in-depth recycled water feasibility study would be required to study all of the potential uses of recycled water in the City. For this analysis, only large-scale irrigation and toilet and urinal flushing for new buildings was considered in calculations for the City's recycled water demand estimate. This limited analysis is intended to capture the "low hanging fruit" in terms of where it would be most practical to deliver and use recycled water.

4.6.3 Potential Areas Served by Recycled Water

Figure 4-2 shows the location of potential recycled water customers within the MPMW service area. The initial phase would likely serve large irrigation customers in the Lower Zone like the St. Patrick's Seminary and University, the Civic Center, and the landscaping area planned for the Facebook Expansion Project. Within MPMW, the total annual recycled water use for irrigation purposes is estimated at 377 AFY while total annual recycled water use for toilet/urinal flushing in new buildings is estimated at 154 AFY. Therefore, the total estimated recycled water demand for a future recycled water project covering the entire MPMW is 531 AFY. Of this total demand, the demand for the Lower Zone is about 353 AFY, while the demand for the Upper Zone is about 179 AFY. [2]

This chapter evaluates the feasibility of implementing a recycled water program, assuming that the MPMW would be able to negotiate with Redwood City or Palo Alto to purchase recycled water and construct its own facilities to deliver the water.

The analysis presented in this section examines potential uses and required infrastructure to serve water to potential irrigation customers and toilet/urinal flushing water for new buildings in the MPMW service area. This analysis does not include a market analysis to assess actual interest in recycled water.

[2] See Section 4.5.4 for the basis of estimates.

The recycled water analysis estimates recycled water demands for areas most likely to accept recycled water, identifies infrastructure required to serve the identified demands, and develops estimated costs that can be used during the economic feasibility analysis. The methodology and results used for the recycled water system feasibility analysis are discussed below, followed by a brief discussion on recycled water supply reliability.

4.6.4 Estimated Recycled Water Demands

Potential recycled water customers include existing potable irrigation customers, such as parks, golf courses, and schools. At the time of this analysis, WBSD was only in the planning phase of a recycled water project that would serve the Sharon Heights Golf Course, so the project was included in this assessment to keep the study as inclusive of all potential recycled water customers with the MPMW boundaries.

Water demands for the existing irrigation customers were determined by first estimating application factors that account for the percentage of area actually irrigated, adopting a unit demand factor for applied recycled water, identifying all potential cemeteries, parks and schools within the MPMW service area, and then estimating costs for infrastructure to serve recycled water. Water demand estimates for the non-potable indoor use customers were calculated as percentages of the estimated Facebook Campus Expansion project indoor water demands included in the February 2016 Water Supply Assessment Study for the Facebook Campus Expansion. The outdoor irrigation water demands associated with the Facebook Campus Expansion project were extracted directly from the same Water Supply Assessment (Erler & Kalinowski, 2016). It should be noted that demand estimates represent the estimated maximum potential demands, if all irrigation and indoor uses were served by non-potable water.

4.6.4.1 Unit Demand Factors and Application Areas for Irrigation with Recycled Water

Recycled water unit demand factors were estimated for the study using reference evapotranspiration data (ETo) from the California Irrigation Management Information System (CIMIS). ETo values are developed for a standard, or reference crop, typically grass. CIMIS publishes a map of ETo values for different climate zones within California. Menlo Park is in Zone 6, Upland Central Coast and has an ETo of 49.7 inches/year. This value was used to compute total irrigation demand. Net irrigation demand was computed by subtracting the average annual precipitation for Menlo Park. Because a rainfall gage was not readily available in Menlo Park and Menlo Park is between Redwood City to the north and Palo Alto to the south, the average annual precipitation was taken as an average between Redwood City's and Palo Alto's long-term annual total precipitation averages. Therefore, the average annual total precipitation in Menlo Park is estimated to be about 17.6 inches[3]. A net irrigation demand of 32.1 inches/year was used in the analysis.

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[3] According to the Western Regional Climate Center database, the total annual average precipitation for Redwood City between 1948 and 2006 was 19.95 inches and the total annual average precipitation for Palo Alto between 1953 and 2015 was 15.21 inches. Therefore, the annual average precipitation in Menlo Park is estimated to be about 17.6 inches (i.e. the average of Redwood City's and Palo Alto's precipitation.) Source: http://www.wrcc.dri.edu/cgi-bin/cliMAIN.pl?ca6646

Recycled water was assumed to only be applied to those areas with a water demand and not applied to areas consisting of buildings, parking lots, or other non-irrigated portions of the cemetery, park, or school. Consequently, application factors were adopted that reduce the gross area of the cemetery, park, or school so that recycled water demands are estimated for irrigable areas only. Table 4-8 presents the application factors developed for this study. The factors for cemeteries, parks, and schools were developed from previous West Yost studies. As shown in Table 4-8, 80 percent of the area associated with cemeteries and parks and 50 percent of the area associated with schools are assumed to be irrigated with recycled water. No application factor was needed for golf courses because an annual irrigation demand value was provided for the one golf course in the MPMW service area.

Table 4-8. Application Factors for Cemeteries, Parks, and Schools[a]

Cemeteries or Parks	Schools
80% of the available area	50% of the available area

(a) Factors for cemeteries, parks, and schools developed from previous West Yost studies.

4.6.4.2 Location of Potential Customers and Projected Recycled Water Demand

Using aerial photographs, West Yost identified parks, schools, and a golf course within the MPMW service area that could potentially use recycled water for irrigation, calculated their acreage using GIS tools, and calculated water demand. No cemeteries were identified within MPMW boundaries. While this analysis is based on existing land uses, the planned Facebook Campus Expansion project was included as part of the recycled water demand assessment. The Facebook project is located in the M-2 Zoning Area and consists of 962,400 sq. ft. of office space, 174,800 sq. ft. of hotel space and 12.9 acres of landscaped area, all of which will replace existing commercial and industrial uses.

Table 4-9 presents the projected annual recycled water demands, and Figure 4-2 illustrates their location within the City. As shown in Table 4-9, the total projected recycled water demand for these existing and new customers within MPMW is approximately 531 AFY with application sites distributed throughout the City.

Table 4-9. Projected Annual Recycled Water Demands in MPMW Service Area

Customer Type	Gross Area, acres	Application Factor	Irrigable Area, acres	Unit Demand, in/yr	Annual Demand, AF
Park	41.0	80%	32.8	32.1	87.7
School	84.0	50%	42.0	32.1	112.4
Golf Course[(a)]	170.0	NA	NA	NA	152.0
Landscape Area Associated with Facebook Expansion	12.9	NA	12.9	NA	25.0
Subtotal Irrigation Applications	307.9		190.4		377.1
New Office Buildings	22.1[(b)]	NA	NA	NA	151.6
New Hotel Building	4.0[(c)]	NA	NA	NA	2.3
Subtotal Non-Potable Indoor Applications[(d)]	26.1				153.9
Total	**334**				**531**

(a) Acreage and annual demand provided in West Bay Sanitary District's 2015 Mitigated Negative Declaration for the Sharon Heights Golf Course Recycled Water Project.
(b) 22.1 acres = 962,400 square feet
(c) 4.0 acres = 174,800 square feet
(d) Non-potable indoor uses include toilet and urinal flushing, estimated as 65 percent of total indoor demand for office buildings and 15 percent of total indoor demand for hotels.

Because MPMW serves the eastern and western sections of the City, it would not be practical to deliver recycled water from the same recycled water project to both the Upper and Lower Zones of MPMW service area. In the Lower Zone, the source of recycled water would likely come from either Redwood City or Palo Alto near the eastern side of Menlo Park.[4] Since delivering recycled water to the Upper Zone from the Lower Zone is impractical, the development of a recycled water program in the Upper Zone would likely need to focus on decentralized and on-site recycled water systems. As discussed earlier in this report, the WBSD completed a Facilities Plan for a recycled water treatment facility at the 170-acre Sharon Heights Golf and Country Club, which is located in the Upper Zone of MPMW. This recycled water plant would supply the Sharon Heights area with recycled water for irrigation and nearby industrial users.

Table 4-10 shows the projected annual recycled water demands for only the Lower Zone. The total projected recycled water demand for the potential recycled water customers within the Lower Zone of MPMW is approximately 353 AFY. That is 199 AFY in irrigation demand and 154 AFY in indoor use demand. The projected annual recycled water demands for the Upper Zone is shown in Table 4-11. The projected recycled water demand for the Upper Zone is 179 AFY.

[4] At the time of this analysis, the focus was to evaluate projects from Redwood City or Palo Alto. Separately, MPMW is collaborating with WBSD to evaluate project options in the Lower and High Pressure zone.

Table 4-10. Projected Annual Recycled Water Demands for the Lower Zone					
Customer Type	Gross Area, acres	Application Factor	Irrigable Area, acres	Unit Demand, inches/year	Annual Demand, AF
Park	38.0	80%	30.4	32.1	81.3
School	69.0	50%	34.5	32.1	92.3
Landscape Area Associated with Facebook Expansion	12.9	NA	12.9	NA	25.0
Subtotal Irrigation Applications	119.9		77.8		198.6
New Office Buildings	22.1[a]	NA	NA	NA	151.6
New Hotel Building	4.0[b]	NA	NA	NA	2.3
Subtotal Non-Potable Indoor Applications[c]	26.1				153.9
Total	**146.0**				**352.5**

(a) 22.1 acres = 962,400 square feet

(b) 4.0 acres = 174,800 square feet

(c) Non-potable indoor uses include toilet and urinal flushing, estimated as 65 percent of total indoor demand for office buildings and 15 percent of total indoor demand for hotels.

Table 4-11. Projected Annual Recycled Water Demands for the Upper Zone					
Customer Type	Gross Area, acres	Application Factor	Irrigable Area, acres	Unit Demand, in/yr	Annual Demand, AF
Golf Course[a]	170.0	NA	NA	NA	152.0
Park	3.0	80%	2.4	32.1	6.4
School	15.0	50%	7.5	32.1	20.1
Subtotal Irrigation Applications	188.0		112.6		178.5
New Office Buildings	0	NA	NA	NA	0
New Hotel Building	0	NA	NA	NA	0
Subtotal Non-Potable Indoor Applications	0				0
Total	**188.0**				**178.5**

(a) Acreage and annual demand provided in West Bay Sanitary District's 2015 Mitigated Negative Declaration for the Sharon Heights Golf Course Recycled Water Project.

4.6.4.3 Peak Irrigation Recycled Water Demand

For evaluating infrastructure requirements, peak irrigation recycled water demands were determined using peaking factors estimated from CIMIS seasonal data and previous West Yost studies. The CIMIS Zone map indicates that the highest monthly ETo is about one and a half times higher than the average daily ETo. Maximum demand day was assumed to be 67 percent higher than the maximum monthly value, for an overall maximum day peaking factor of 2.5 times the average daily use. Irrigation use is assumed to occur at night-time, over an 8-hour irrigation window. Therefore, a total peaking factor of 7.5 (2.5 x 24/8) times the average daily water use was used to estimate the peak water use requirement.

Table 4-12 presents the Lower Zone peak demand in gallons per minute (gpm). As shown in Table 4-10, the peak demand associated with service to all potential irrigation customers in the MPMW's Lower Zone is approximately 923 gpm (or approximately 1.33 mgd)

Upper Zone peak demands are presented in gpm in Table 4-13. All potential customers in the Upper Zone are irrigation customers and are estimated to have a peak demand of 830 gpm (1.2 mgd).

Table 4-12. Peak Recycled Water Demands for Irrigation in the Lower Zone

Average Annual Irrigation Demand, AF	Average Day Demand, gpm	Peaking Factor	Peak Flow, gpm
198.6	123	7.5	923

Table 4-13. Peak Recycled Water Demands for Irrigation in the Upper Zone

Average Annual Irrigation Demand, AF	Average Day Demand, gpm	Peaking Factor	Peak Flow, gpm
178.5	110.6	7.5	829.5

4.6.4.4 Peak Indoor Recycled Water Demand

Peak recycled water demands for indoor non-potable use for toilet and urinal flushing were determined by multiplying a factor of 2.0 to the average annual demand to account for max day demand as well as multiplying by another factor of 2.0 to the max day demand to account for the peak hour demand. Therefore, a total peaking factor of 4.0 (2.0 x 2.0) was applied to the average daily water use to estimate the peak water use requirement.

Table 4-14 presents the peak demands in gpm. As shown in Table 4-12, the peak demand associated with service to all potential non-potable indoor use customers in MPMW's Lower Zone is approximately 381 gpm (or approximately 0.55 mgd).

Table 4-14. Peak Recycled Water Demands for Indoor Use in the Lower Zone

Average Annual Irrigation Demand, AF	Average Day Demand, gpm	Peaking Factor	Peak Flow, gpm
153.9	95.4	4.0	381

4.6.5 Infrastructure Requirements for Service to Projected Recycled Water Demands

The focus of this study is on developing the costs for a distribution system that would serve the Lower Zone since it is closer to the potential sources of recycled water and, therefore less expensive and more likely to be cost-effective. Potential transmission main alignments to serve the projected recycled water demands in the Lower Zone were identified for estimating potential capital facility costs to serve parks, schools, business park landscaping, and the buildings associated with the new Facebook expansion project with recycled water. As shown on Figures 4-3 and 4-4, the pipeline alignments tie into either the 12- or 14-inch diameter recycled water mains from the north (that are being proposed as part of Redwood City's Phase 2 project [see Figure 4-3])[5] or the recycled water main from the south (that would come from East Palo Alto as part of the City of Palo Alto's Phase 4 project [see Figure 4-4]). The size of the main that would come from Palo Alto is yet to be determined. It is assumed that water would be delivered to a small recycled water storage tank just inside of the City limits, near the tie-in location, and that a pump station would boost the recycled water to the appropriate service pressure.

Pipelines were sized using sizing criteria for new pipelines requiring a maximum head loss of no more than three feet per 1,000 feet of pipeline and a maximum velocity of no more than 5 feet per second. Therefore, the recycled water mains coming from either Redwood City or Palo Alto need to be 12-inch diameter pipes. The approximate sizing of pipelines for both the Redwood City and Palo Alto options (Options #1 and Option #2, respectively) are shown in Figures 4-3 and 4-4. Pump station sizing was based on providing a firm capacity of 2.0 mgd, based on calculated peak demands, and a tank capacity of 10,000 gallons was assumed. Costs for the new pipelines[6], pump station, and tank were estimated using unit costs developed for previous Master Plan studies, with unit costs escalated using an October 2015 Engineering News Record Construction Cost Index (ENR CCI) for San Francisco of 11169.

4.6.6 Infrastructure and Other Implementation Costs

Table 4-15 presents the estimated facilities and associated capital costs. As shown in Table 4-15, the total estimated capital cost for recycled water distribution facilities is approximately $13.1M for Option #1 and $12.0M for Option #2. The annual revenue requirement for these capital facilities is $886,000/year, using Option #1 costs to be conservative, assuming a 50-year project life with pump station electrical and mechanical equipment replacement at 25 years and a five percent interest rate. O&M costs are not separately estimated, except for energy costs, which, assuming $0.15/kWh, are estimated to be about $80,000/yr. Based on these costs, this supply option has a unit cost of about $2,500/AF ($5.8/HCF). This cost however, does not include the cost to purchase the water from either city. If it is assumed that the cost to purchase recycled water

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[5] Menlo Park is interested in receiving recycled water from Redwood City from a pipeline north of Highway 101 - which would be an extension of the Stanford Alternate Pipeline, Option 1B as shown in Figure 4-3. However, Redwood City originally suggested that Menlo Park receive recycled water as an extension of their Phase II pipeline that would be south of Highway 101, coming from the Stanford Medical Center, Option 1A as shown in Figure 4-3. Both Options 1A and 1B are shown on Figure 4-3 as the preferred pipeline route for Redwood City and Menlo Park has not yet been determined.

[6] The Option 1A pipeline from Redwood City was used in the Option #1 cost estimate. Costs to construct Option 1B pipeline are expected to be higher than Option 1A due to a longer pipe length.

is the same as what Redwood City charges its current customers for debt-normalized wholesale recycled water, $6/HCF (or $2,600/AF), then the total cost of delivered recycled water to MPMW customers would be about $5,100/AF ($11.7/HCF). In addition to the $6/HCF, a separate buy-in cost to Redwood City or Palo Alto may also be required. This compares with the current (FY 2017/18) SFPUC wholes water charge of $1,786/acre-foot plus meter capacity fees (SFPUC, 2017).

Table 4-15. Summary of Capital Costs for Recycled Water System in the Lower Zone[a]

Item	Option #1 Redwood City Cost, dollars	Option #2 Palo Alto Cost, dollars
Steel Storage Tank (10,000 gallons)	50,000	50,000
Booster Station (2.0 mgd, firm capacity)	1,499,000	1,499,000
12-inch diameter pipeline (8,970 ft for Option #1; 6,058 ft for Option #2)	2,422,000	1,636,000
8-inch diameter pipeline and smaller (18,833 ft for Option #1 and 19,611 ft for Option #2)[b]	3,767,000	3,922,000
Subtotal	$7,738,000	$7,107,000
Construction Contingency (30%)	2,321,000	2,132,000
Subtotal	$10,059,000	$9,239,000
Implementation Multiplier (30%)[c]	3,018,000	2,772,000
Total Capital Cost of Recycled Water System[d]	**$13,077,000**	**$12,011,000**

(a) Based on ENR Index for San Francisco of October 2015 (11169).
(b) The lengths shown here include all pipes expected to be 8 inches and smaller.
(c) Implementation Costs are estimated to be 30 percent, including include design, Construction Management, Administration and Legal expenses
(d) Total Capital Cost of Recycled System rounded to the nearest $1,000.

4.6.7 Recycled Water Supply Reliability

Recycled water supply will likely either come from Redwood City or Palo Alto. The reliability of each of these sources is dependent on the reliability of their wastewater treatment facilities and distribution system. Both Redwood City and Palo Alto currently deliver recycled water within their own jurisdictions and have a record of excellent reliability. Therefore, if Menlo Park purchases water from either of these cities, the recycled water supply that could be delivered would be expected to have high reliability.

4.7 RECOMMENDATIONS

Based on the observations and evaluations made in this chapter, the following recommendations are suggested.

- In tandem with existing conservation programs, MPMW should develop a simple informational graywater program which points interested customers to County's staff and website, or other available resources, in response to its customers' requests for guidance on graywater systems.
- MPMW should consider including dual-plumbing requirements in the City code, for new commercial facilities to be able to receive treated graywater or recycled water for non-potable indoor and outdoor use in the future.
- MPMW should continue to pursue a recycled water program to address potential future potable water shortfalls during drought conditions and as service area growth increases.
- MPMW should continue discussions with both staff and elected officials from Redwood City and Palo Alto regarding receiving recycled water.
- MPMW should perform an analysis of recycled water opportunities in the Bayfront Area to explore the feasibility of implementing recycled water and/or non-potable stormwater, and re-evaluate options once this study is completed.

The capital improvement program presented in Chapter 9 includes a line item for continuation of recycled water studies.

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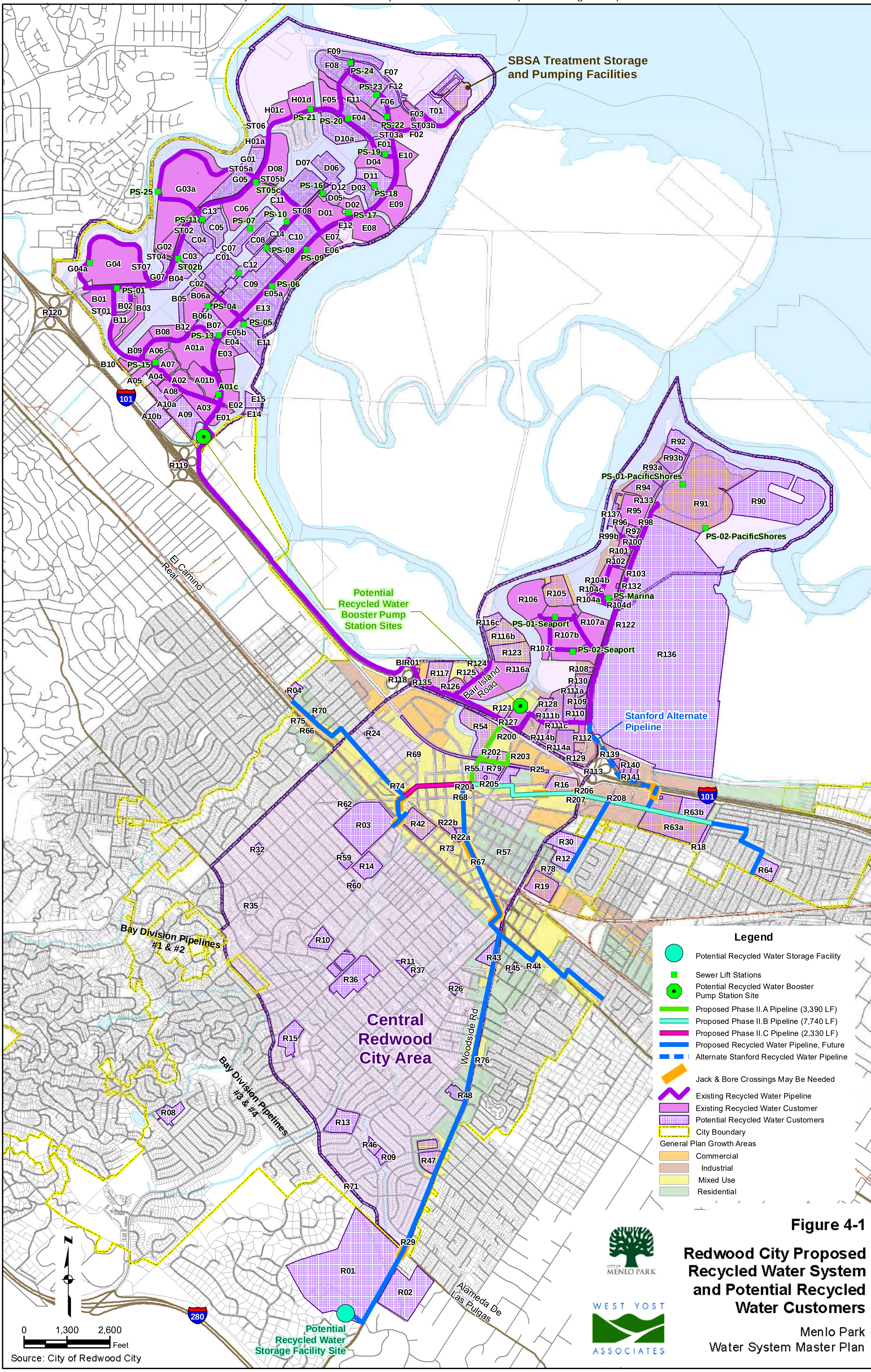

Figure 4-1

Redwood City Proposed Recycled Water System and Potential Recycled Water Customers

Menlo Park Water System Master Plan

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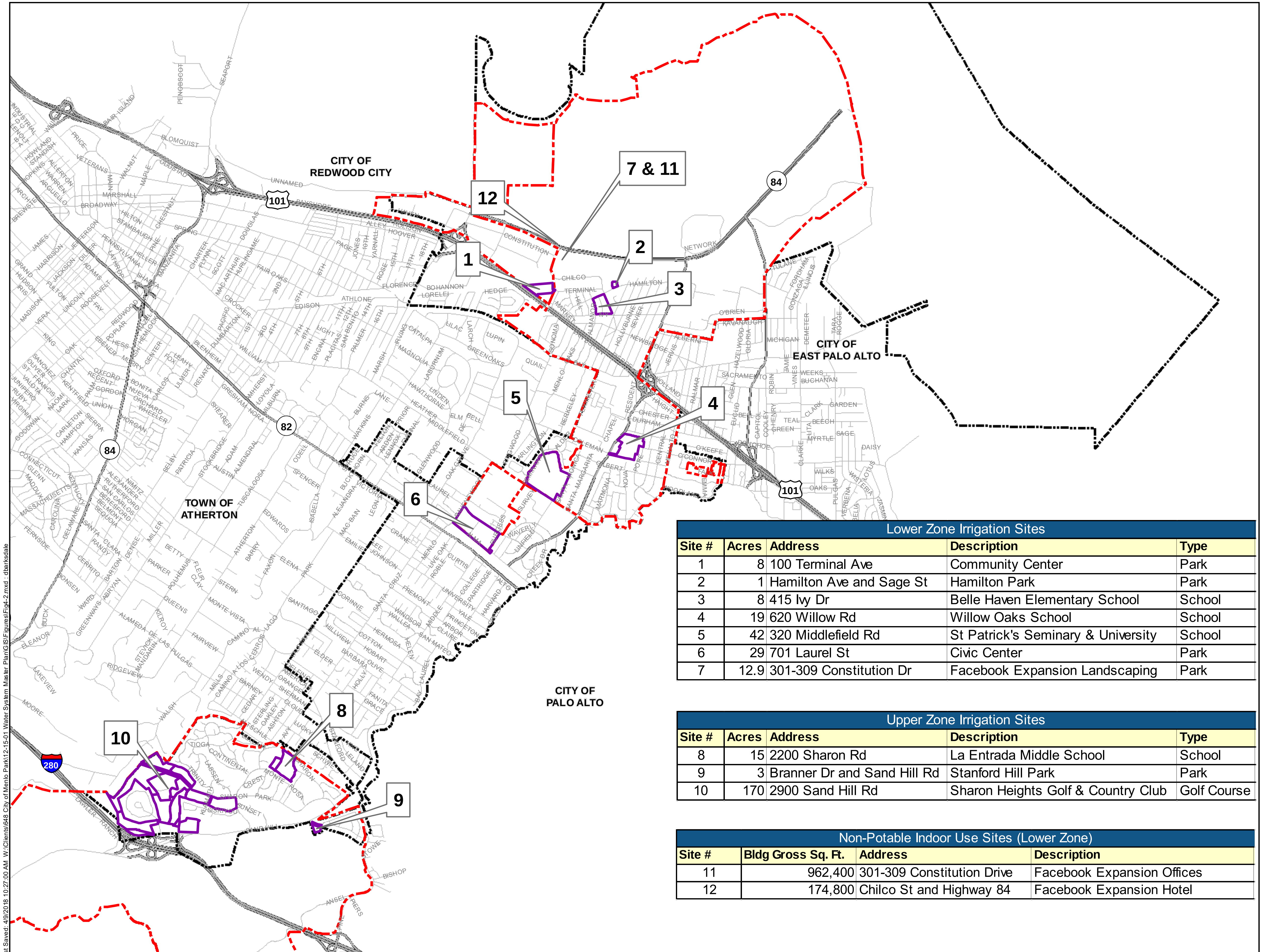


Lower Zone Irrigation Sites

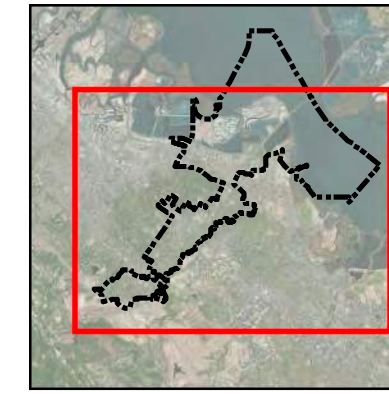
Site #	Acres	Address	Description	Type
1	8	100 Terminal Ave	Community Center	Park
2	1	Hamilton Ave and Sage St	Hamilton Park	Park
3	8	415 Ivy Dr	Belle Haven Elementary School	School
4	19	620 Willow Rd	Willow Oaks School	School
5	42	320 Middlefield Rd	St Patrick's Seminary & University	School
6	29	701 Laurel St	Civic Center	Park
7	12.9	301-309 Constitution Dr	Facebook Expansion Landscaping	Park

Upper Zone Irrigation Sites

Site #	Acres	Address	Description	Type
8	15	2200 Sharon Rd	La Entrada Middle School	School
9	3	Branner Dr and Sand Hill Rd	Stanford Hill Park	Park
10	170	2900 Sand Hill Rd	Sharon Heights Golf & Country Club	Golf Course

Non-Potable Indoor Use Sites (Lower Zone)

Site #	Bldg Gross Sq. Ft.	Address	Description
11	962,400	301-309 Constitution Drive	Facebook Expansion Offices
12	174,800	Chilco St and Highway 84	Facebook Expansion Hotel



0 1,800 3,600
Scale in Feet

Potential Recycled Water Customers
Service Area Boundary
City Limits

CITY OF MENLO PARK
WEST YOST ASSOCIATES

Figure 4-2
Potential Recycled Water Customers

Menlo Park Municipal Water
Water System Master Plan

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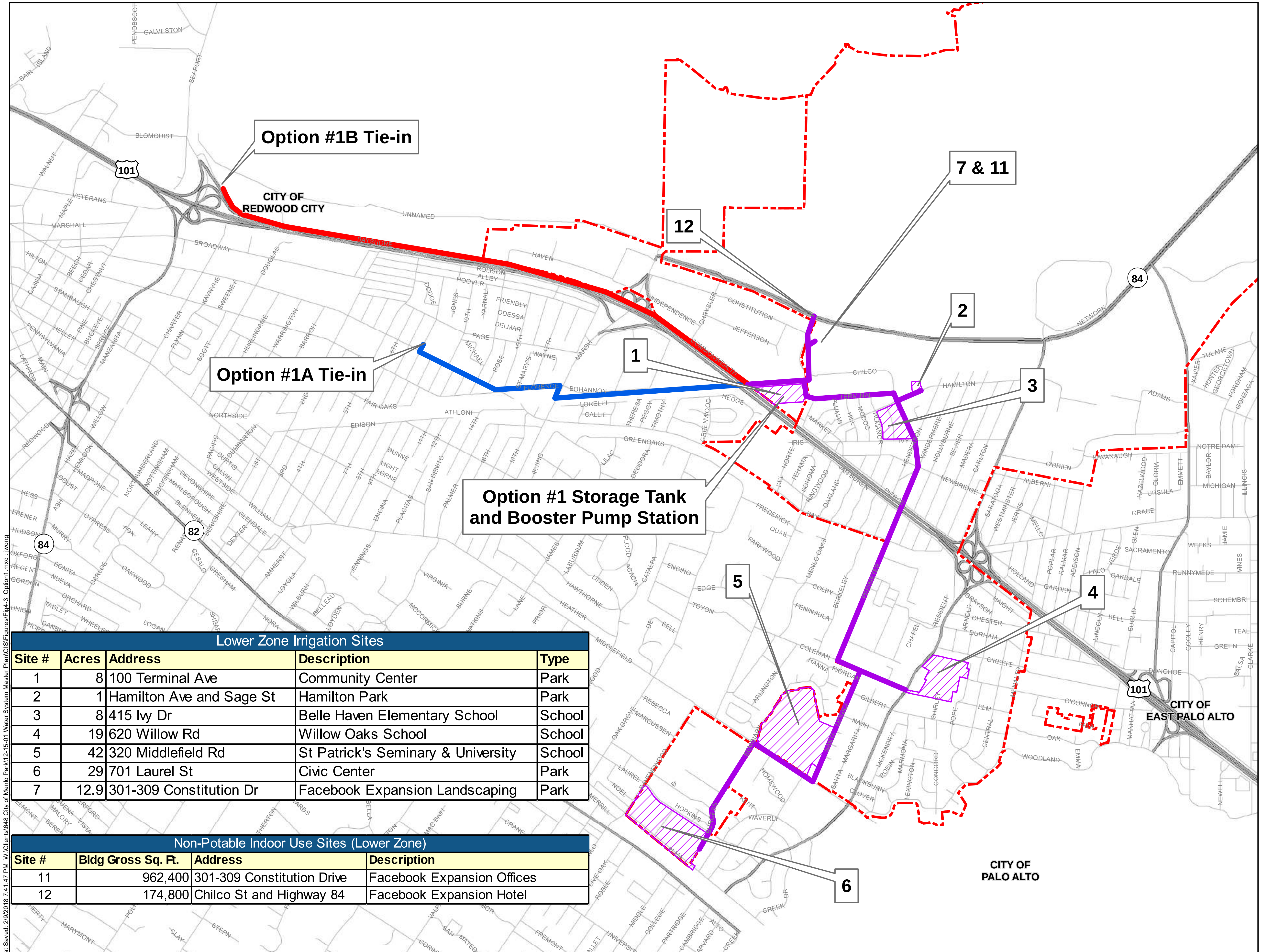
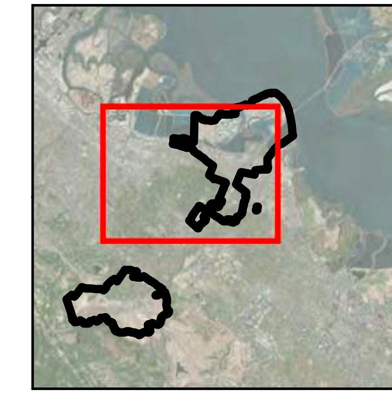


Lower Zone Irrigation Sites

Site #	Acres	Address	Description	Type
1	8	100 Terminal Ave	Community Center	Park
2	1	Hamilton Ave and Sage St	Hamilton Park	Park
3	8	415 Ivy Dr	Belle Haven Elementary School	School
4	19	620 Willow Rd	Willow Oaks School	School
5	42	320 Middlefield Rd	St Patrick's Seminary & University	School
6	29	701 Laurel St	Civic Center	Park
7	12.9	301-309 Constitution Dr	Facebook Expansion Landscaping	Park

Non-Potable Indoor Use Sites (Lower Zone)

Site #	Bldg Gross Sq. Ft.	Address	Description
11	962,400	301-309 Constitution Drive	Facebook Expansion Offices
12	174,800	Chilco St and Highway 84	Facebook Expansion Hotel



- Potential Pipeline Layout Option 1
- Potential Pipeline Layout Option 1A
- Potential Pipeline Layout Option 1B
- Existing or Planned Redwood City Recycled Water Pipe
- Potential Recycled Water Customers
- Service Area Boundary

Figure 4-3
Option 1: Potential Layout of Recycled Water Pipelines if Served from Redwood City

Menlo Park Municipal Water
Water System Master Plan

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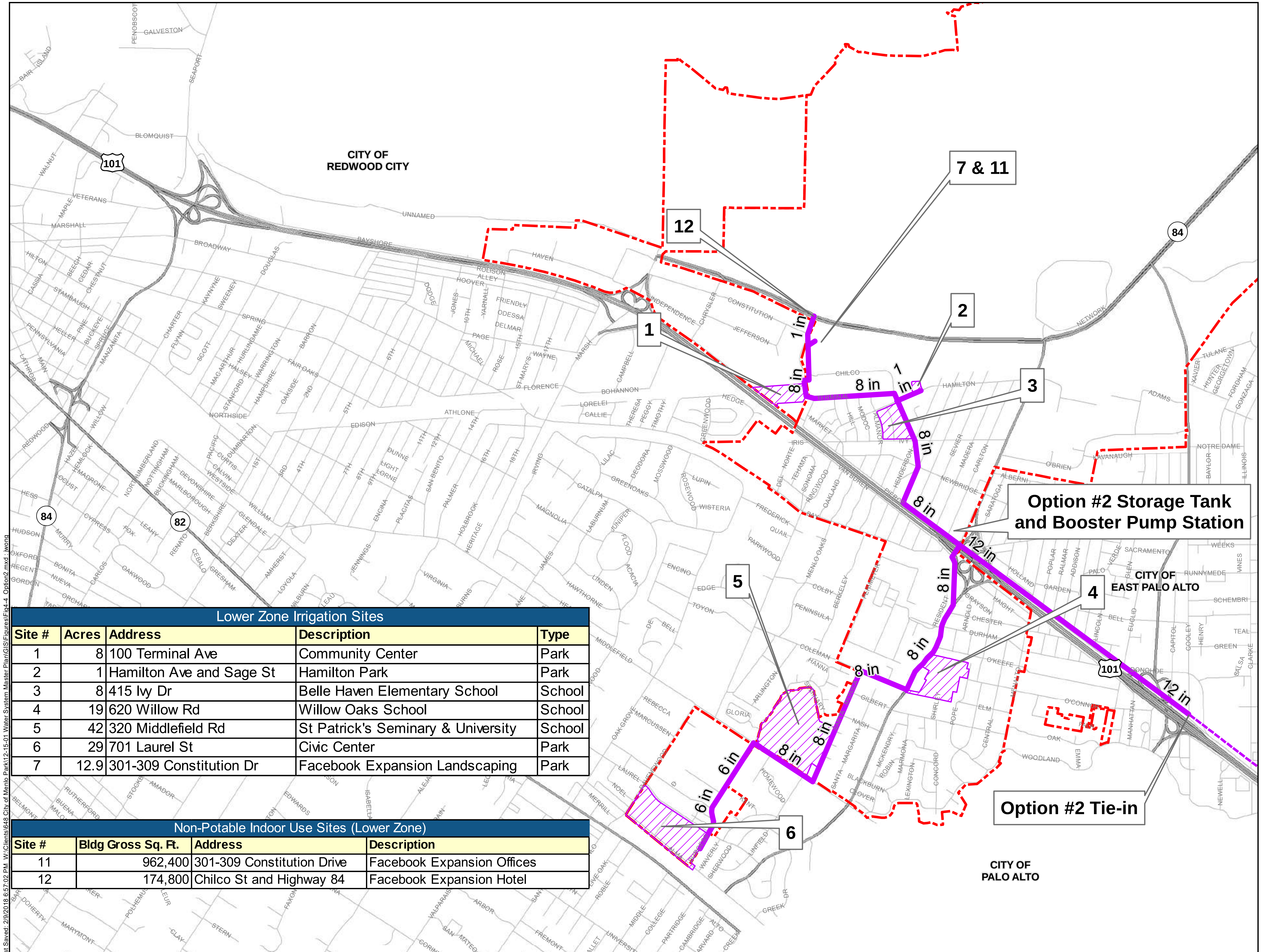

Lower Zone Irrigation Sites				
Site #	Acres	Address	Description	Type
1	8	100 Terminal Ave	Community Center	Park
2	1	Hamilton Ave and Sage St	Hamilton Park	Park
3	8	415 Ivy Dr	Belle Haven Elementary School	School
4	19	620 Willow Rd	Willow Oaks School	School
5	42	320 Middlefield Rd	St Patrick's Seminary & University	School
6	29	701 Laurel St	Civic Center	Park
7	12.9	301-309 Constitution Dr	Facebook Expansion Landscaping	Park

Non-Potable Indoor Use Sites (Lower Zone)			
Site #	Bldg Gross Sq. Ft.	Address	Description
11	962,400	301-309 Constitution Drive	Facebook Expansion Offices
12	174,800	Chilco St and Highway 84	Facebook Expansion Hotel

Figure 4-4
Option 2: Potential Layout of Recycled Water Pipelines if Served from Palo Alto

Menlo Park Municipal Water
Water System Master Plan

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5.1 OVERVIEW

This chapter defines the recommended planning and design criteria to be used for evaluating the performance of MPMW's water distribution system.

Key water system planning and design criteria from the 2000 Water System Evaluation Report have been incorporated into this chapter; however, some of the previous criteria have been revised to reflect more recent or suitable standards for this WSMP. The following sections of this chapter present the recommended planning and design criteria for MPMW's potable water distribution system:

- General Water System Reliability and Recommendations
- Water System Performance
- Facilities Sizing

Table 5-1 summarizes the recommended water system planning and design criteria for MPMW which are discussed in more detail below.

5.2 GENERAL WATER SYSTEM RELIABILITY AND RECOMMENDATIONS

Water system reliability is achieved through a number of system features including: (1) appropriately sized storage facilities; (2) redundant or "firm" pumping and transmission facilities where required; (3) emergency water supplies (groundwater wells and interties); and, (4) alternate power supplies. Reliability and water quality are also improved by designing looped water distribution pipelines and avoiding dead-end distribution mains whenever possible. Looping pipeline configurations reduces the potential for stagnant water and the associated problems of poor taste and low disinfectant residuals. In addition, proper valve placement is also necessary to maintain reliable and flexible system operation under normal and abnormal operating conditions.

5.2.1 Water Quality Standards

Water quality standards largely pertain to protecting public health and consistently delivering a satisfactory product to the customer. The United States Environmental Protection Agency (USEPA) and the State Water Resources Control Board (SWRCB) Division of Drinking Water (DDW) are responsible for establishing water quality standards. USEPA and the SWRCB prescribe regulations that limit the amount of certain contaminants in water provided by a public water system. MPMW, as a consecutive system, is responsible for ensuring that the applicable water quality standards and regulations are met at all times.

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Table 5-1. Summary of Recommended Water System Performance and Operational Criteria

Component	Criteria	Remarks / Issues
WATER SYSTEM PERFORMANCE		
Fire Flow Requirements		
Single Family Residential	500 gpm @ 2 hours	Refer to Table 5-2 for explanation of values. These are requirements for new developments, assumed to be sprinklered, and were used to evaluate future development areas. Flows can be supplied by multiple hydrants. Improvements for existing development were evaluated on case-by-case basis. Source: MPFPD.
Multi-Family Residential	4,000 gpm @ 4 hours	
Commercial	4,000 gpm @ 4 hours	
Industrial	4,000 gpm @ 4 hours	
Institutional/Governmental	4,000 gpm @ 4 hours	
Peak Supply Capacity		
Peak Water Demands - Normal Operating Conditions	_Zones with storage:_ Provide firm supply capacity equal to maximum day demand; meet peak hour demand from a combination of supply capacity and balancing storage. _Zones without storage:_ Provide firm supply capacity equal to peak hour demand.	Zones without storage are those which do not have direct access to storage facilities. Water supplies to these zones must be capable of meeting peak hour demand.
Peak Water Demands - Fire Flow Conditions	_Zones with storage:_ Meet maximum day demand plus fire flow from a combination of supply capacity and balancing storage. _Zones without storage:_ Provide peak hour demand plus fire flow from supply capacity.	Zones without storage are those which do not have direct access to storage facilities. Fire flow may be provided by an adjacent zone if interconnections exist, but the supply sources directly serving the zone must have sufficient capacity to supply the recommended fire flow concurrent with a maximum day demand condition.
Distribution System Pressures		
Minimum Pressure - Normal Operating Conditions	40 psi at customer service connection	Services with pressure less than 40 psi require an individual booster pump.
Maximum Pressure	80 psi at customer service connection 120 psi at customer service connections in High Pressure Area	Services with pressure greater than 80 psi require an individual pressure reducing valve.
Minimum Pressure - Fire Flow Conditions	20 psi	
FACILITIES SIZING		
Booster Pump Station Capacity		
Pumping Capacity	Firm pumping capacity equal to maximum day demand	Firm booster pumping capacity defined as the total capacity of all pumps minus the capacity of the largest pumping unit.
Backup Power	Equal to the firm capacity of the pumping facility.	On-site generator for critical stations.[a] Plug-in portable generator for less critical stations.
Pressure Regulating Station Capacity		
Valve Capacity	Valve capacity equal to the peak hour demand plus fire flow where the pressure reducing station is sole supply source.	
Storage Facility Capacity		
Operational Storage	0.25 x maximum day demand	
Emergency Storage	0.5 x maximum day demand	For emergencies such as power outages when pump stations may not be in service.
Fire Flow Storage	Fire flow demand for the most severe fire recommended in the pressure zone multiplied by the recommended duration	See Table 6-2.
Groundwater Credit (GC)	Equal to the firm groundwater supply that can be reliably accessed (_i.e.,_ facilities equipped with auxiliary power).	Maximum credit equal to recommended emergency storage capacity.
Total Water Storage Capacity	1.0 x maximum day demand + Fire Flow Storage - Groundwater Credit	
Water Transmission Pipelines (12-inch diameter or larger)[b]		
Diameter	12-inch or larger	Locate new transmission pipelines within designated utility corridors wherever possible.
Maximum Velocity - Normal Conditions	4 ft/s	
Maximum Velocity - Fire Flow Conditions	7 ft/s	
Maximum Headloss - Normal Conditions	3 ft of loss per 1,000 ft of pipeline	
Maximum Headloss - Fire Flow Conditions	5 ft of loss per 1,000 ft of pipeline	
Hazen Williams "C" Factor	130	For consistency in hydraulic modeling.
Pipeline Material	DI, Welded Steel	For consistency in hydraulic modeling.
Water Distribution Pipelines (Less than 12-inch diameter)[b]		
Minimum Pipeline Diameter	8-inch	Locate new distribution pipelines or looping connection within designated utility corridors wherever possible.
Maximum Velocity - Normal Conditions	5 ft/s	
Maximum Velocity - Fire Flow Conditions	12 ft/s (maximum)	
Hazen Williams "C" Factor	130	For consistency in hydraulic modeling.
Pipeline Material	PVC, DI	For consistency in hydraulic modeling.

[a] A booster pump station is defined as critical if it provides service to pressure zone(s) and/or service area(s) without sufficient fire or emergency storage or meets the following criteria:

- The largest facility that provides water to a particular pressure zone and/or service area;
- A facility that provides the sole source of water to single or multiple pressure zones and/or service areas; or
- A facility that provides water from a supply turnout.

[b] Recommended pipeline velocity and headloss criteria are used for sizing new pipelines. Existing pipelines not meeting the recommended criteria would not be identified as deficient unless there are also pressure deficiencies.

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5.2.2 Fire Flow Requirements

MPMW, which resides within MPMW of Menlo Park Public Works Department, operates and maintains the city-owned water distribution system. The Menlo Park Fire District (MPFD) is concerned with the availability of adequate water supply and pressure for firefighting purposes. Consequently, MPFD establishes minimum flows and residual system pressures during a firefighting event.

MPFD uses the California Fire Code (CFC), 2013 edition, which establishes minimum fire flows and durations for individual structures (refer to Appendix B of the 2013 CFC). In contrast, this WSMP evaluates available fire flow capacity by using general land use categories that represent different types of development to assess distribution system adequacy under current and future water demand conditions. Therefore, the fire flow requirements set forth in this WSMP are intended only for general planning purposes and is not reflective of the actual fire flow requirements sought for specific development approvals, and does not identify specific existing non-conforming developments. Table 5-2 presents the recommended minimum requirements based on general land use designations and guidelines from the MPFD Fire Marshal.

It should be noted that the ISO Rating criteria is different than the 2013 CFC it specifies fire flow rates (and durations) using different methodology; but similar in that fire flow rates (and durations) are specified on a building-by-building basis. In general, for 1 to 2- family dwellings, the 2013 CFC specifies that the minimum fire flow and duration is 1,000 gpm for 1 hour. The ISO Rating criteria would specify a needed fire flow that ranges from 500 gpm to 1,500 gpm (based on separation distance) and would have an associated duration of 2 hours. For larger residential buildings, the maximum fire flow per ISO would be 3,500; and using the 2013 CFC this requirement would be based on the square footage. Larger buildings, not used for residential purposes, would be entirely based on area and building type for the 2013 CFC or; construction type, area, occupancy, exposure, and communication factors for ISO.

For the purposes of the master plan, these precise calculations are not done on a building by building basis; rather, fire flow requirements are assumed based on land use types. The fire flow requirements summarized in Table 5-2 are based on the 2013 CFC. For example, the largest fire flow requirement in the 2013 CFC is 8,000 gpm for 4 hours; and was assigned based to the multi-family, commercial, institutional, and industrial commercial land uses. Single family residential land uses were assigned 1,500 gpm for two hours, and is applicable for homes less than or equal to 3,600 sq ft (and is the largest value that the ISO Criteria requires).

The minimum fire flows identified in Table 5-2 are to be met concurrently during an assumed maximum day demand, for zones with storage, or a peak hour demand, for zones with no storage, while maintaining a minimum residual system pressure of 20 psi throughout the water system. The fire flow requirements shown in Table 5-2 will be used for the evaluation of the MPMW water system under future water demand conditions to confirm sizing of future system improvements. Additionally, as discussed in subsequent sections of this chapter, the minimum fire flows presented in Table 5-2 and their expected duration will also be used to establish the fire flow storage capacity requirements.

Table 5-2. Recommended Fire Flow Requirements[a,b,c]

Land Use Designation	Non-Sprinklered			Sprinklered[d]		
	Fire Flow, gpm	Duration, hours	Recommended Storage, MG	Fire Flow, gpm	Duration, hours	Recommended Storage, MG
Single Family Residential	1,000	2	0.12	500	2	0.06
Multi-Family Residential	8,000	3	1.44	4,000	3	0.72
Commercial	8,000	4	1.92	4,000	4	0.96
Industrial	8,000	4	1.92	4,000	4	0.96
Institutional/Governmental	8,000	4	1.92	4,000	4	0.96

(a) Construction type and fire flow calculation area are not generally known during the development of a Water Master Plan; consequently, fire flow requirements set forth in this table are based on previous estimates for these land use types and similar communities. Existing land use refers to current conditions and new will be the future/buildout development scenario.

(b) Unique projects or projects with alternate materials may require higher fire flows and should be reviewed by the Fire Marshal on a case-by-case basis (e.g., proposed commercial/industrial areas, hospitals, schools, etc.).

(c) Fire flow requirements assume that existing buildings are not sprinklered to be conservative for planning purposes.

(d) As outlined in the *Menlo Park Fire District Standard Fire Protection Systems Installation of Fire Sprinkler Systems*. Fire Marshal normally allows up to a 50 percent reduction in CFC fire flow requirements if a building is provided with an automatic sprinkler system. However, the CFC also requires that no fire flow be less than 1,000 gpm for single family residential or 1,500 gpm for all other building types. For a more conservative fire flow estimate, Single Family and Multiple Family Residential buildings were considered non-sprinklered for this Water Master Plan. Certain commercial, industrial and institutional/governmental buildings, known to be sprinklered, were provided to West Yost and incorporated in the hydraulic model. The remaining were assumed to be non-spinklered. For future conditions, All buildings were assumed to be sprinklered.

For this WSMP, fire flows are analyzed for both sprinklered and non-sprinklered conditions. Improvements are developed using sprinklered fire flow criteria, since new developments are required to have sprinklers and existing developments are assumed to meet the fire flow standards that were in place at the time of development.

5.3 WATER SYSTEM PERFORMANCE

5.3.1 Peak Supply Capacity

MPMW currently receives its entire water supply from the SFPUC's RWS through five water supply turnouts, and water is delivered to MPMW's Lower High Pressure, and Upper Zones. Only the Upper Zone has storage.

Peak hour demand and maximum day demand plus fire flow conditions are used to assess the adequacy of MPMW's water system facilities and transmission/distribution pipelines during high demand periods. Adopted peaking factors to represent maximum day and peak hour demands are discussed in *Chapter 3 Water Demands*.

Supply Capacity, Zones with Storage: Peak supply capacity should be capable of meeting the maximum day demand, with peak hour demands met from a combination of zone supply and storage. Maximum day demand plus fire flow is also met from a combination of zone supply and storage.

Supply Capacity, Zones without Storage: Peak supply capacity must be capable of meeting peak hour demands, under normal operating conditions, and peak hour demands plus fire flows for fire flow conditions, since no storage is available to supplement the supply sources.

5.3.2 Distribution System Pressures

Adequate system pressure is a basic indicator of acceptable water distribution system performance. The recommended performance planning criteria for system pressures are:

- Allowable Pressures Under Normal Operating Conditions: 40 psi to 80 psi[1]
  - — Minimum Pressure under Average Day Demand: 40 psi
  - — Minimum Pressure under Maximum Day Demand: 40 psi
  - — Minimum Pressure under Peak Hour Demand: 40 psi
- Minimum Pressure Under Fire Flow Conditions: 20 psi

These performance criteria are applied to all areas that fall within the normal customer service elevation ranges for each pressure zone. Customers outside of the normal service elevation ranges may require an individual pressure regulator or booster pump. Customers in the Upper Zone and High Pressure Zone are required to have pressure regulators.

[1] The Plumbing Code requires that individual services that exceed 80 psi have an individual pressure regulator on the service line; services that are less than 40 psi during an average day demand condition must have an individual booster pump on the service line. A pressure criterion of 80 psi should be used to design fire protection systems.

5.4 FACILITIES SIZING

5.4.1 Booster Pump Station Capacity

The Sharon Heights Pump Station should have sufficient firm booster pumping capacity to meet maximum day demand, where firm capacity is defined as the total capacity of all pumps minus the capacity of the largest pumping unit. Because the pump station is the sole supply source for the zone, it is equipped with an on-site backup generator.

5.4.2 Storage Facility Capacity

Total treated water storage capacity requirements are evaluated based on the following three components:

- Operational Storage
- Fire Storage
- Emergency Storage

Each storage component is discussed below. The recommended water storage capacity for MPMW's water system will be evaluated by pressure zone.

5.4.2.1 Operational Storage

Typically, operational storage is used to meet water demands in excess of water supply to the zone (e.g., offsetting the peak hour demands). Operational storage is typically replenished during hours when demand is less than the water supply to the zone. Supply is typically provided at a rate equal to maximum day demand.

Operational storage is commonly estimated at 25 percent of the maximum day demand in accordance with AWWA guidelines.[2] The operational storage requirements should be calculated based on the actual diurnal demand in a particular pressure zone. However, in lieu of developing diurnal demand patterns, West Yost recommends that for planning purposes the volume of water to be held in reserve for operational storage should be at least equal to 25 percent of the total volume used during a maximum day demand.

5.4.2.2 Fire Storage

Fire storage is the volume of storage reserved for fire flows. The fire storage volume is determined by multiplying the required maximum fire flow rate by the required duration time. It is assumed that no more than one fire flow event would occur in any pressure zone at one time. Table 5-2 presents the recommended fire flow storage for each land use designation.

[2] "Determining Distribution System Storage Needs", September 2005, AWWA.

5.4.2.3 Emergency Storage

A storage reserve is required to meet demands during an emergency. An emergency is defined as an unforeseen or unplanned event that may degrade the quality or quantity of potable water supplies available to serve customers. Determination of the required volume of emergency storage is a policy decision based on the assessment of the risk of failures and the desired degree of system reliability. The amount of required emergency storage is a function of several factors including the diversity of the supply sources, redundancy and reliability of the production facilities, and the anticipated length of the emergency outage.

The AWWA states that no formula exists for determining the amount of emergency storage required, and that the decision will be made by the individual utility based on a judgment about the perceived vulnerability of the system.[3] For this WSMP, it is recommended that MPMW have a minimum quantity of emergency storage volume equivalent to 50 percent of the maximum day demand, consistent with the 2000 Water System Evaluation Report.

5.4.2.4 Emergency Groundwater Storage Credit

While MPMW currently has no active wells, it is in the process of installing wells in the Lower Zone that are planned to be designated for emergency use. The groundwater basin can account for a portion of the recommended water storage and system peaking capacity in the form of an emergency groundwater storage credit. In the case of MPMW, these facilities would include the capacity of the wells that are equipped with auxiliary power operated over a 24-hour period. The minimum credit is equal to zero, and the maximum credit is equal to the recommended emergency storage capacity (up to 50 percent of the maximum day demand).

5.4.2.5 Total Storage Capacity Recommended

MPMW's recommended total water storage capacity should be the sum of the following components:

- Operational: Volume of water necessary to meet diurnal peaks observed throughout the day, assumed to be equivalent to at least 25 percent of the maximum day demand; plus
- Fire Flow: Volume of water necessary to supply a fire flow event, where the fire flow event is contingent upon the service area; plus
- Emergency: Volume of water necessary to provide an emergency supply of 50 percent of the maximum day demand; minus
- Emergency Groundwater Storage Credit: A groundwater credit equal to the firm groundwater supply that can be reliably accessed to meet emergency needs will be calculated to adjust emergency storage needs from above ground storage.

[3] "Determining Distribution System Storage Needs", September 2005, AWWA.

The amount of total system storage and system peaking capacity required to meet these criteria will change over time as MPMW continues to grow and water demands change.

5.4.3 Pressure Regulating Station Capacity

MPMW's Lower Zone is served solely by pressure regulating stations, and does not have storage. The sum of the total pressure regulating station capacity from all stations should be equal to the peak hour demand plus fire flow.

5.4.4 Pipeline Sizing

The following criteria will be used as guidelines for sizing transmission and distribution system pipelines. Although these criteria and guidelines have been established, and will be used to size new pipelines, MPMW's existing water system will be evaluated using system pressure as the primary criterion. Secondary criteria, such as pipeline velocity, head loss, age, and material type, are used as indicators to locate, and to help prioritize where water system improvements may be needed. Therefore, MPMW's existing system will be evaluated on a case-by-case basis. For example, if an existing pipeline experiences velocity or head loss in excess of the criteria described below, this condition, by itself, does not necessarily indicate a problem as long as the minimum system pressure criterion is satisfied. Other conditions such as pipeline age, material type, and location in the system will also be considered.

5.4.4.1 General Definitions and Standards

The following list summarizes the general definitions and MPMW standards for transmission and distribution pipelines:

- Transmission mains are defined as pipelines with a diameter equal to 12 inches or larger.
- Distribution mains are defined as pipelines with a diameter smaller than 12 inches.
- All new pipelines are required to be polyvinyl chloride or DI.[4]
- All new pipelines are required to have a minimum diameter of 8 inches.
- New pipelines should be located within designated utility corridors wherever possible. These designated utility corridors should be within public rights-of-way to minimize or eliminate the need for utility easements within private property.

[4] As discussed in the seismic evaluation provided in Appendix C, high density polyethylene (HDPE) and molecularly-oriented polyvinyl chloride (PVCO) are recommended as acceptable material types.

5.4.4.2 Water Transmission System

For planning purposes, West Yost recommends the following criteria for water transmission pipelines:

- Normal Conditions
  - Maximum velocity of 4 feet per second (ft/s); and
  - Maximum head loss of 3 feet per thousand feet (ft/kft) of pipeline.
- Fire Flow Conditions
  - Maximum velocity of 6 ft/s; and
  - Maximum head loss of 9 ft/kft of pipeline.

For the existing water system pipelines, pipeline velocity and head loss criteria are not typically used to identify deficient facilities, as long as system pressures are adequate. However, these criteria are used for sizing new transmission system pipeline facilities.

5.4.4.3 Water Distribution System

For planning purposes, West Yost recommends the following criteria for water distribution pipelines:

- Maximum velocity of 5 ft/s during normal operating conditions; and
- Maximum velocity of 12 ft/s during fire flow conditions.

For the existing water system pipelines, pipeline velocity criteria are not typically used to identify deficient facilities, as long as distribution system pressures are adequate. However, these criteria are used for sizing new distribution system pipeline facilities.

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CHAPTER 6
Hydraulic Model Development

This chapter describes the development and calibration of MPMW water system hydraulic model, which was used to evaluate the adequacy of both the existing and proposed future water system. To develop MPMW's hydraulic model, West Yost completed the following tasks:

- Updated MPMW's geodatabase of the water distribution system;
- Created a hydraulic model of the MPMW water distribution system;
- Spatially allocated existing water demands by using MPMW's metered account information to distribute water demands within the hydraulic model;
- Calibrated the hydraulic model system configuration (pipeline sizes, alignments, connections, and other facility size and locations) to simulate MPMW's current pressures, flows, and tank elevations observed in the field during hydrant testing; and,
- Developed diurnal water demand patterns to estimate peaking factors and daily diurnal use.

To accomplish these tasks, West Yost worked closely with MPMW staff to obtain and review available:

- Information regarding existing transmission and distribution mains, storage reservoirs, booster pump station, pressure regulating stations and other water distribution system facilities;
- Metered account water consumption data; and
- Historical SFPUC turnout data.

The water distribution system hydraulic model was calibrated using flow and pressure data collected during in the field during hydrant testing performed on November 16, 2016. The hydraulic model development and calibration are described in the following sections.

6.1 DESCRIPTION OF THE MODEL AND MODEL ELEMENTS

Innovyze's InfoWater program is the hydraulic modeling software used to represent MPMW's water system. This computer simulation model transforms information about the physical water distribution system into a mathematical model that solves for various flow conditions based on the specified water demands and/or system operations. The computer model then generates information on pressure, flow, velocity and head loss that can be used to analyze water system performance and identify deficiencies. The model can also be used to verify the adequacy of recommended or proposed system improvements. For this study, a steady-state (static or snapshot in time) hydraulic model was developed for MPMW for evaluating the existing water distribution system under peak demand conditions. In addition, diurnal demand patterns were prepared to develop an extended period simulation model capable of performing more complex water system hydraulic evaluations (e.g., water quality evaluations).

The hydraulic model is represented as a network of nodes (e.g., tanks, pumps, or locations where pressure is monitored), and node-connecting elements (e.g., pipes). However, because nodes are representative of various actual facilities (e.g., tanks, pump stations, or wells), a definition of each element was established during the development of the hydraulic model. Table 6-1 provides a brief description for each type of node and node-connecting element.

Table 6-1. Description of Model Elements

Model Element	Purpose	Data Requirement(s)
Node	• Represents transitions in pipeline characteristics (e.g., diameter) or points in the system where pressure is monitored • Also represents locations in the system, such as pump station or tank connections, where metered water demands do not exist	• Elevation
Junction	• Represents locations in the system where water demands exist • Also represents transitions in pipeline characteristics (e.g., diameter)	• Elevation • Water demand • Diurnal pattern
Pipe	• Represents facilities that convey water from one point in the system to another, and are used to represent pipelines or check valves	• From/To Node or Junction • Length • Diameter • Hazen-Williams C-factor (roughness factor)
Reservoir	• Represents external sources of water for the model (e.g., SFPUC supply turnout, interconnection), and remain at a constant water level irrespective of the flow unless they are specified as variable head reservoirs	• Water surface elevation
Tank	• Tanks have known volumes and water surface elevations that change with time as water flows into or out of the facility • Represents MPMW's storage reservoirs	• Volume at various depths • Bottom and overflow elevations
Pump	• Represents locations where the hydraulic grade line is raised to overcome elevation differences and friction losses	• Elevation • Pump curve • Pump efficiency test results
Valve	• Regulates either flow or pressure	• Elevation • Diameter • Setting

6.2 DEVELOPMENT OF THE HYDRAULIC MODEL

West Yost developed a hydraulic model of MPMW's water system using a series of steps that included the following:

- Imported pipelines from MPMW's GIS, and added nodes and junctions;
- Assigned pipeline roughness factor (C-factor);
- Allocated elevations to nodes and junctions;
- Incorporated water system facilities;
- Applied a naming scheme to each model element;
- Spatially located meter accounts in GIS; and
- Allocated water demands in the hydraulic model.

Each of these steps is discussed in the following sections.

6.2.1 Pipelines, Nodes, and Junctions

MPMW staff worked with West Yost to develop an updated geodatabase containing the spatial location and attribute data of existing pipelines and other water facilities within MPMW's water distribution system. The updated geodatabase was based on MPMW's existing GIS and was updated using information collected during the system wide field verification conducted by West Yost staff. During the field verification, West Yost collected spatial and attribute information of various water system facilities, which was used to confirm water system facilities and pipeline alignments. West Yost also used the ESRI topology tool to help identify and resolve any connectivity errors prior to importing the water pipeline feature class into the model. This effort is described in more detail in Appendix A.

After importing the water pipeline feature class into the hydraulic model, West Yost used InfoWater's Append Nodes tool to create and assign the beginning and end-points (from and to nodes) to the pipelines. West Yost also developed an attribute field in the hydraulic model database to include the pipe element's unique FacilityID, which was developed as part of the geodatabase update (see Appendix A), to facilitate the ability to leverage or integrate model information with MPMW's GIS. It should be noted that it is West Yost's understanding that MPMW plans to develop GIS unique IDs (GUIDs) for all assets, separate from the FacilityID. However, this GUID has not yet been developed. As a result, West Yost included a GUID attribute field into the hydraulic model database to allow for inclusion of the GUIDs once they have been developed. This inclusion of this field in the hydraulic model will streamline future updates to the hydraulic model and will help maintain parity between the Department's GIS and hydraulic model.

6.2.2 Pipeline Characteristics

MPMW's existing pipeline shapefile for existing water pipelines did not include roughness factors. However, MPMW's shapefile contained attributes which identified pipeline material type and diameter. Consequently, West Yost assigned a preliminary roughness factor (i.e., C-factor) based on experience and professional judgment to each pipeline by using its diameter and pipeline material type. Table 6-2 presents the preliminary C-factors assigned to each of the different pipeline material types within MPMW's water system. These C-factors were then confirmed during calibration of the hydraulic model, as described in *Section 6.4 Hydraulic Model Calibration*.

Table 6-2. Preliminary Pipeline C-factors Assigned in the Hydraulic Model

Pipeline Material	C-factor	
	Diameter ≤ 8-inches	Diameter > 8-inches
Asbestos Cement (AC)	120	130
Cast Iron (CI)	90	100
Ductile Iron (DI or DW)	130	140
Earthquake Resistant Ductile Iron (ERDI)	140	150
Polyvinyl Chloride (PVC)	140	150
Steel (STL or WS)	110	120
Unknown (UNK)	120	130
High Density Polyethylene (HDPE)	140	150

[(a)] Refer to Table 6-7 for a final summary of the C-factors used in the hydraulic model.

6.2.3 System Elevations

MPMW's service area has a fairly wide range of customer service elevations, with elevations ranging between 5 to 70 feet msl in the Lower and High Pressure Zones and between 159 to 452 feet msl in the Upper Zone. West Yost obtained elevation data from the National Hydrography Dataset (NHD) program shared by the USGS. For the Menlo Park area, data was collected using Light Detection and Ranging (LiDAR), a remote sensing method which provides high accuracy elevation data. The elevation data was collected in 2013. The 2013 NHD data was used to assign service elevations to each node or junction in the hydraulic model. Elevations were spot checked with elevation data collected by West Yost during field visits to ensure its accuracy. The vertical datum of the elevation shapefile is in North American Vertical Datum of 1988 (NAVD 88).

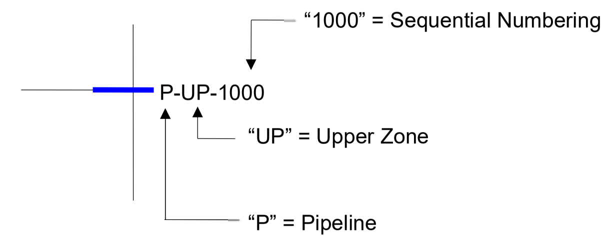
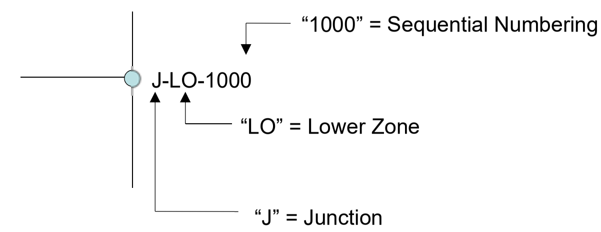
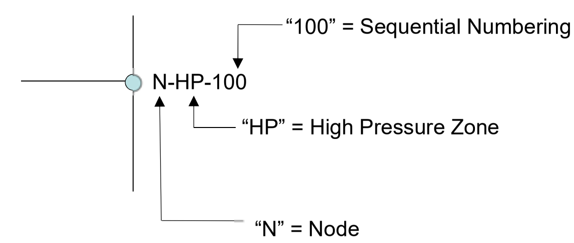
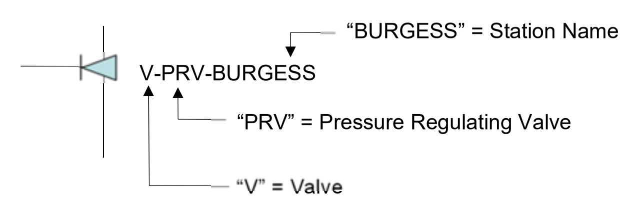
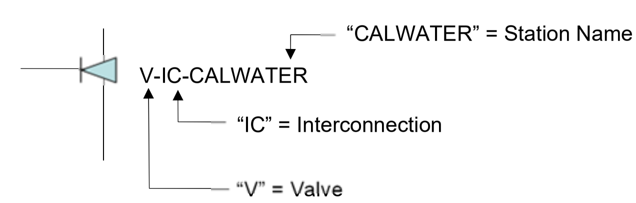
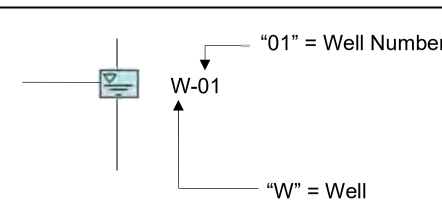
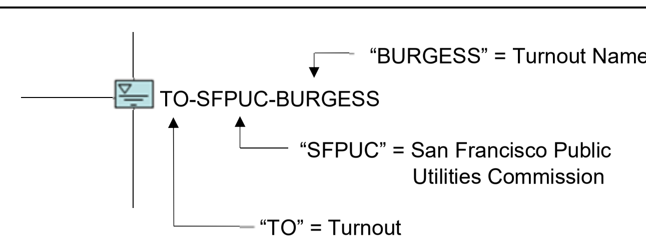
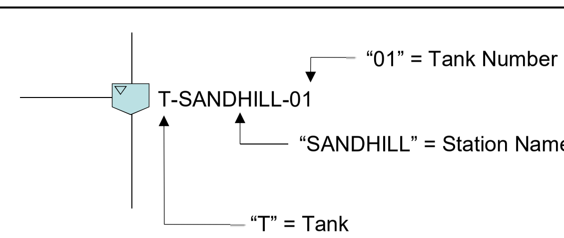
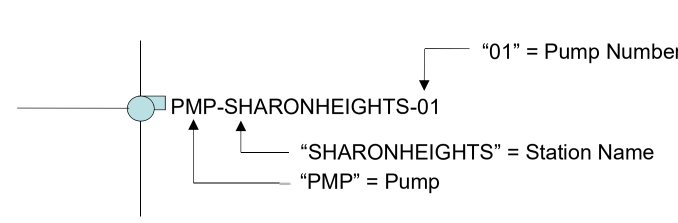
6.2.4 Water System Facilities

After the pipelines and nodes/junctions were incorporated into the hydraulic model, major system facilities (e.g., turnouts, pressure reducing valves, pump station, and storage reservoirs) were digitized into the hydraulic model. Each of these facilities was entered into the model based on drawings and other available information provided by City staff.

6.2.5 Naming Scheme for Model Elements

After the major system facilities were digitized into the model, each model element was assigned a label which identifies the type of model element, the pressure zone where the element is located, and a sequential numerical value. By assigning each model element a unique model ID, users of the hydraulic model will be able to easily locate specific elements or more readily identify potential problems during the calibration and system evaluation process. MPMW's hydraulic model was populated using the naming scheme presented in Table 6-3.

Table 6-3. Naming Scheme for Hydraulic Model Network Elements

Model Element	Naming Scheme
Pipelines	
Junctions	
Nodes	
Pressure Regulating Stations	
Interconnections/ Emergency Interties	
Wells	
Turnouts	
Storage Reservoirs	
Pumps	

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6.2.6 Consumption Data

After discussions with MPMW staff, it was agreed that average water production data from calendar year 2013 would be used to represent MPMW's existing "baseline" water demands for the hydraulic model. MPMW staff provided West Yost with a shapefile of spatially-located 2013 average water consumption data. The shapefile was plotted in GIS and reviewed for any anomalies. The 2013 water consumption records were subsequently scaled to match the production from SFPUC turnouts.

SRI International is served directly from the SFPUC Turnout at 650 El Camino Real via a bypass at the Burgess PRV station. Since the private pipelines that connect to the SRI International meter are not included in the GIS, the SRI International consumption had to be manually located. Figure 6-1 compares the spatially located water consumption records with the existing pipelines imported into InfoWater. As shown on Figure 6-1, most areas with spatially located consumption records also had an existing pipeline. This correlation indicates that the GIS shapefile used as the basis for the hydraulic model includes most of the existing pipelines required to serve existing water demands.

6.2.7 Water Demand Allocation

Water demands were allocated in the hydraulic model using the spatially located consumption data described in the previous section. The model's Demand Allocator tool analyzes the spatially located consumption data to identify the closest pipeline to each consumption point. The tool then applies the water consumption to the closest junction of the selected pipeline. West Yost staff then reviewed the allocated water demand to confirm that the demands were allocated properly.

Water demand within the hydraulic model is stored in a data table that allows demands to be input into up to 10 columns. Demands were assigned to the table by six customer sectors to provide City staff with additional flexibility for analysis of customer records. Table 6-4 presents the demand column assigned to each customer sector within the hydraulic model.

Table 6-4. Customer Sector Assignment

Customer Sector	Demand Column in Model[a]
Single Family Residential	1
Multi-Family Residential	2
Business and Commercial	3
Industrial	4
Irrigation	5
Public Authority	6
Other and Private Fire	7

(a) Column number corresponds to Demand # Column in the junction database of the InfoWater model.

6.3 HYDRAULIC MODEL CALIBRATION

MPMW's hydraulic model was calibrated to confirm that the computer simulation model can accurately represent the operation of MPMW's water distribution system under varying conditions. Calibration of the hydraulic model used data gathered through hydrant tests as described in the following sections.

6.3.1 Development of Hydrant (C-Factor) Tests

After developing the hydraulic model, six locations (and two alternates) were chosen for possible hydrant flow testing as shown on Figure 6-2. Selection of these hydrant test sites was based on specific pipeline size and material type. These hydrant tests were used to evaluate pipeline friction factors (C-factors) and to calibrate the model to ensure that the hydraulic model closely represented actual observed pressure conditions in the field. West Yost provided MPMW with a memorandum detailing the hydrant test procedures before performing the field testing (see Appendix B).

Hydrant flow testing was performed on November 16, 2016. Table 6-5 provides the field status of each hydrant test. All six of the hydrant tests (not including 2 alternates), scheduled for November 16, 2016, were performed. Each hydrant test involved flowing water through pipelines of a specific size and material type[1], and then measuring the pressure drops through the pipelines to determine friction losses. The hydrant test procedure consisted of monitoring discharge flow and pressure at the key flowing hydrant, and pressures at other hydrants along the supply route to the flowing hydrant. Static pressures were measured while the flow hydrant was closed, and residual pressures were measured while the hydrant was flowing.

Each hydrant test typically has three or four observed hydrants. These observed hydrants are identified by the test number and then an alphanumeric designation based on their location in relation to the flowing hydrant with A being the closest and D being the farthest. For example, in Test 2, the first observed hydrant closest to the hydrant which is being flowed is referred to as Hydrant 2A; the next hydrant is Hydrant 2B, etc.

Prior to any model simulations, each pipeline was assigned a preliminary C-factor, based on the pipeline size and material type as presented in Table 6-2. Consequently, each hydrant flow test performed was then simulated using the hydraulic model of MPMW's water system. Results were compared to the field data to determine the accuracy of the hydraulic model. The differences between observed static and residual pressures for the field hydrant test were calculated and compared to readings predicted by the model. The goal of the calibration effort was to achieve no greater than a 5 psi differential between the field hydrant test data and model-simulated results, based on standard engineering practice for model calibration in water system master planning.[2] Results from the hydrant tests are discussed in more detail in the following section.

[1] For each hydrant test, system valves were closed as necessary to isolate pipelines of a specific size and material type.

[2] Computer Modeling of Water Distribution Systems, AWWA M32, 2012, page 88.

Table 6-5. Hydrant Test Locations and Status[a]				
Test #	Pipeline Material Type	Pipeline Diameter, inches	Location	Field Status
1	Asbestos Cement (AC)	8	Sharon Road, south of intersection with Altschul Avenue	Completed
2	Earthquake Resistant Ductile Iron (ERDI)	8	East side of Trinity Drive, south of Tioga Drive	Completed
3	AC	8	Intersection with Coleman Avenue and Riordan Place	Completed
4	Unknown	10	Southwest corner of parking lot, south of O'Brien Drive	Completed
5	Ductile Iron (DI)	8	Ginger Street, intersection with Sandlewood Street	Completed
6	AC	10	Haven Avenue	Completed
7A (Alternate)	DI	6	McKendry Drive, intersection with Robin Way	Canceled
8A (Alternate)	AC	10	Constitution Drive, intersection with Jefferson Drive	Canceled

[a] Six Test Locations and two Alternate Test Locations.

6.3.2 Hydrant (C-Factor) Test Results

The results of the simulated hydrant flow tests indicate that localized adjustments needed to be made and therefore, C-factors previously shown in Table 6-2 required some adjustments. Further discussion regarding these tests is provided below.

6.3.2.1 Test 1 (8-inch AC)

The initial difference between field-observed and model-simulated differential pressures for the observed hydrants exceeded the 5 psi pressure tolerance limit. Without any changes to the system configuration or the initial C-factors, the field-observed and model-simulated differential pressures differed by as much as 26 psi. To address this error, the C-factor for AC pipe within the Upper Pressure Zone was increased to 140. The field-observed and model-simulated differential pressures with this adjustment resulted in an average difference of -4 psi at the observed hydrants.

6.3.2.2 Test 2 (8-inch ERDI)

The initial difference between field-observed and model-simulated differential pressures for the observed hydrants exceeded the 5 psi pressure tolerance limit. Without any changes to the system configuration or the initial C-factors, the field-observed and model-simulated static pressures are differential pressures differed by as much as 15 psi. To address this error, the C-factor for the ERDI pipe in the Upper Pressure Zone was increased to 145. The field-observed and model-simulated differential pressures with this adjustment resulted in an average difference of 1 psi at the observed hydrants.

6.3.2.3 Test 3 (8-inch AC)

No changes were required since the field-observed and model-simulated differential pressures have an average difference of 2 psi at the observed hydrants.

6.3.2.4 Test 4 (10-inch Unknown)

No changes were required since the field-observed and model-simulated differential pressures have an average difference of 0 psi at the observed hydrants.

6.3.2.5 Test 5 (8-inch DI)

The initial difference between field-observed and model-simulated differential pressures for the observed hydrants exceeded the pressure tolerance limit. Without any changes to the system configuration or the initial C-factors, the field-observed and model-simulated differential pressures differ by as much as 14 psi. To address this error, the C-factor for AC pipe in the High Pressure Zone was adjusted to 140 for pipes greater than 8-inches in diameter and 130 for pipes less than or equal to 8-inches in diameter. The field-observed and model-simulated differential pressures with this adjustment resulted in an average difference of -2 psi at the observed hydrants.

6.3.2.6 Test 6 (10-inch AC)

The initial difference between field-observed and model-simulated differential pressures for the observed hydrants exceeded the pressure tolerance limit. Without any changes to the system configuration or the initial C-factors, the field-observed and model-simulated differential pressures differ by as much as 14 psi. By increasing the C-factor for AC pipe in the High Pressure Zone to 140 for pipes greater than 8-inches in diameter and 130 for pipes less than or equal to 8-inches in diameter, the field-observed and model-simulated differential pressures can be nearly equated, with an average difference of -2 psi at the observed hydrants.

6.3.3 Hydraulic Model Calibration Findings and Conclusions

In summary, the results from the hydrant tests indicate that the hydraulic model is generally well calibrated within a 5 psi pressure differential from field-observed data with adjustments to the initial C-factors assigned in the hydraulic model. Results of the final calibration are shown in Table 6-6. The revised C-factors are summarized in Table 6-7 below.

In the Upper and High Pressure Zones, the C-factor for AC was increased. In the lower zone, the C-factor for AC seemed to be lower than in the High Pressure and Upper Pressure zones. This is possibly due to the fact that the AC pipe in the Lower Zone is generally older than in the rest of the system. Other C-factor adjustments include increasing the C-factor for the ERDI pipeline recently installed in the Upper Pressure Zone and increasing the C-factor for small diameter (less than or equal to 8-inches in diameter) DI pipelines in the Lower Pressure Zone. These results indicate that MPMW's hydraulic model can accurately simulate a fire flow or other large demand conditions within MPMW.

Table 6-6. Summary of Hydrant Test Calibration Results								
	Field Data			Modeled Data				
Hydrant[a]	Static Pressure, psi	Residual Pressure, psi	Differential Pressure, psi (Static - Residual)	Static Pressure, psi	Residual Pressure, psi	Differential Pressure, psi (Static - Residual)	Comparison of Differential Pressures Data[b]	Average Line Segment Differential Pressure
Hydrant Flow Test No. 1 in Upper Zone at approximately 1,500 gpm [Sharon Road, south of intersection with Altschul Avenue]								
1A (Not Observed)								-4
1B	132	52	80	132	52	81	-1	
1C	140	80	60	133	68	65	-5	
1D	133	87	46	133	81	52	-6	
Hydrant Flow Test No. 2 in Upper Zone at approximately 1,460 gpm [East side of Trinity Drive, south of Tioga Drive]								
2A	95	55	40	97	52	45	-5	1
2B	108	76	32	108	76	32	0	
2C	108	81	27	102	80	23	4	
2D	106	86	20	105	91	14	6	
Hydrant Flow Test No. 3 in Lower Zone at approximately 1,150 gpm[Intersection with Coleman Avenue and Riordan Place]								
3A	66	34	32	62	28	34	-2	2
3B	69	41	28	63	36	27	1	
3C	71	51	20	63	49	14	6	
Hydrant Flow Test No. 4 in Lower Zone at approximately 1,450 gpm[Southwest corner of parking lot, south of O'Brien Drive]								
4A								0
4B	80	40	40	79	34	45	-5	
4C	82	46	36	79	43	36	0	
4D	80	45	35	79	48	31	4	
Hydrant Flow Test No. 5 in Lower Zone at approximately 1,560 gpm[Ginger Street, intersection with Sandlewood Street]								
5A	82	36	46	80	30	50	-4	-2
5B	82	41	41	79	38	41	0	
5C	83	51	32	79	44	36	-4	
5D	79	54	25	79	52	27	-2	
Hydrant Flow Test No. 6 in High Pressure Zone at approximately 2,590 gpm[Haven Avenue]								
6A	135	76	59	135	69	65	-6	-2
6B	140	86	54	135	77	57	-3	
6C	135	84	51	135	89	46	5	
6D (Not Observed)								

[a] Location of hydrants are shown on Figure 6-2.

[b] The goal of the calibration effort is to achieve an average line segment differential pressure comparison within 5 psi for observed hydrants.

Table 6-7. Summary of Calibrated Pipeline C-Factors Assigned in the Hydraulic Model

Material	Lower Pressure Zone		High Pressure Zone		Upper Pressure Zone	
	Less ≤ 8-inches	Greater > 8-inches	Less ≤ 8-inches	Greater > 8-inches	Less ≤ 8-inches	Greater > 8-inches
AC	120	130	130	140	140	140
CI	90	100	-	-	-	-
DI	135	140	130	140	130	140
DW	-	140	-	-	-	-
ERDI	-	-	-	-	145	-
HDPE	140	150	-			
PVC	140	150	140	150		
STL	110	120	-	-	-	-
UNK	120	130	-	120	120	130

6.4 DIURNAL WATER DEMAND FACTORS AND PATTERNS

Hourly diurnal water demand patterns were developed using hourly turnout deliveries for the maximum demand day in 2016. West Yost used the hourly data to identify the corresponding diurnal use and peak hour to maximum day peaking factors for the three pressure zones. The resulting diurnal demand patterns are summarized on Figure 6-3. Table 6-8 summarizes the resulting peaking factors by pressure zone.

MPMW reviewed 2016 daily turnout data and provided hourly turnout deliveries for the maximum delivery day, which was July 25, 2016 for the Lower Zone and High Zone. The daily and hourly data were used to develop a maximum day to average day peaking factor, and a peak hour to maximum day peaking factor. Daily turnout data could not be used to calculate Upper Zone maximum day use, because the Sharon Heights PS operates only intermittently to re-fill the Sand Hill Reservoirs. The ratio of maximum day to maximum month Lower Zone deliveries was used to scale up maximum month Upper Zone use to estimate a maximum day delivery.

Hourly diurnal patterns were calculated for both the Lower Zone and the High Pressure Zone, using the turnout data. A diurnal demand pattern for the Upper Pressure Zone was not directly calculated due to the size of the Sand Hill Reservoirs and the difficulty of accurately estimating flow rates out of the reservoirs. Therefore, the diurnal pattern for the Upper Pressure Zone was approximated by using the Lower Zone diurnal pattern as a surrogate, and adjusting the peak hour to maximum day peaking factor to 2.0 to more accurately represent the residential demands of the Upper Pressure Zone.

Table 6-8. Summary of Peaking Factors by Pressure Zone[a]

Pressure Zone	ADD to MDD	MDD to PHD
Lower Zone	1.5	1.4
High Pressure Zone	2.6	4.0
Upper Zone[b]	1.9	2.0

(a) Peaking factors based on daily and hourly meter data from SFPUC.
(b) Upper Zone max day demand peaking factor based on the ratio of max month to average day, scaled up by an additional 15 percent, to account for daily variations. Peak Hour factor is based on a max day to peak hour peaking factor of approximately 2.0, consistent for areas largely comprised of residential land uses.

6.5 OVERALL HYDRAULIC MODEL DEVELOPMENT AND CALIBRATION FINDINGS AND CONCLUSIONS

Overall, the results from the calibration process validated the system configuration and demand allocation in the hydraulic model. It is recommended that the City continue to update/verify pipeline system configuration in the model as new facilities are constructed. Based on the results of the hydraulic model calibration, it can be concluded that the hydraulic model provides and accurate representation of MPMW's water distribution system, and is adequate for use as a planning tool.

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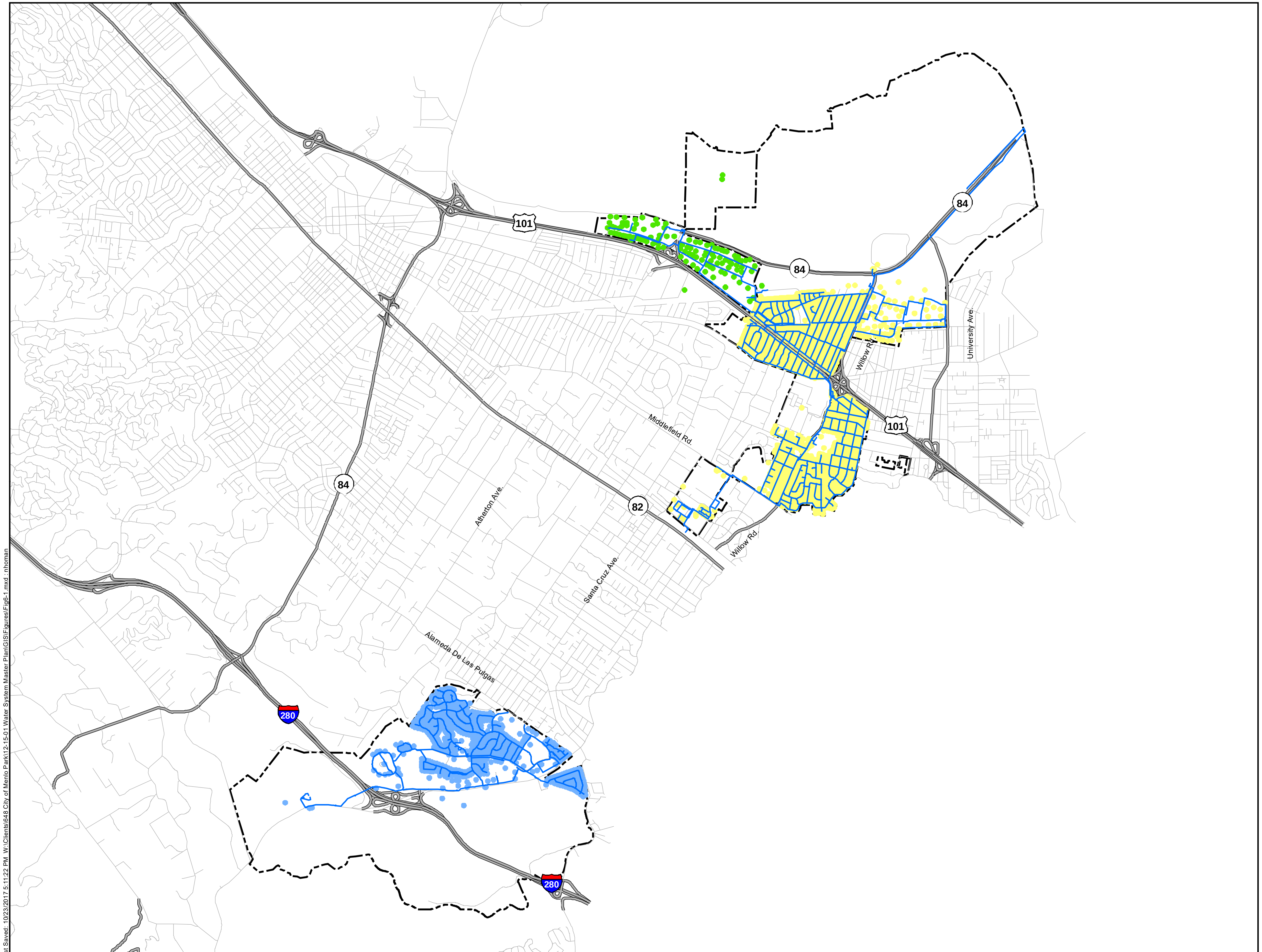

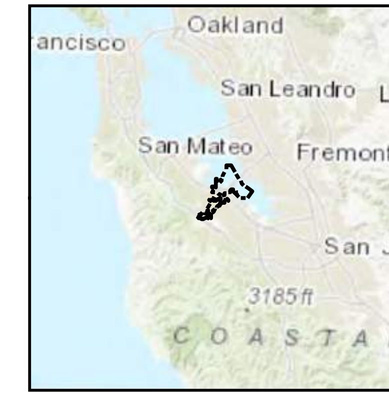

N

0 2,000 4,000
Feet

Symbology

Spatially Located Demand

- High Pressure
- Lower
- Upper
- Pipeline
- Service Area Boundary

CITY OF MENLO PARK

WEST YOST ASSOCIATES

Figure 6-1

Spatially Located Water Demands

Menlo Park Municipal Water
Water System Master Plan

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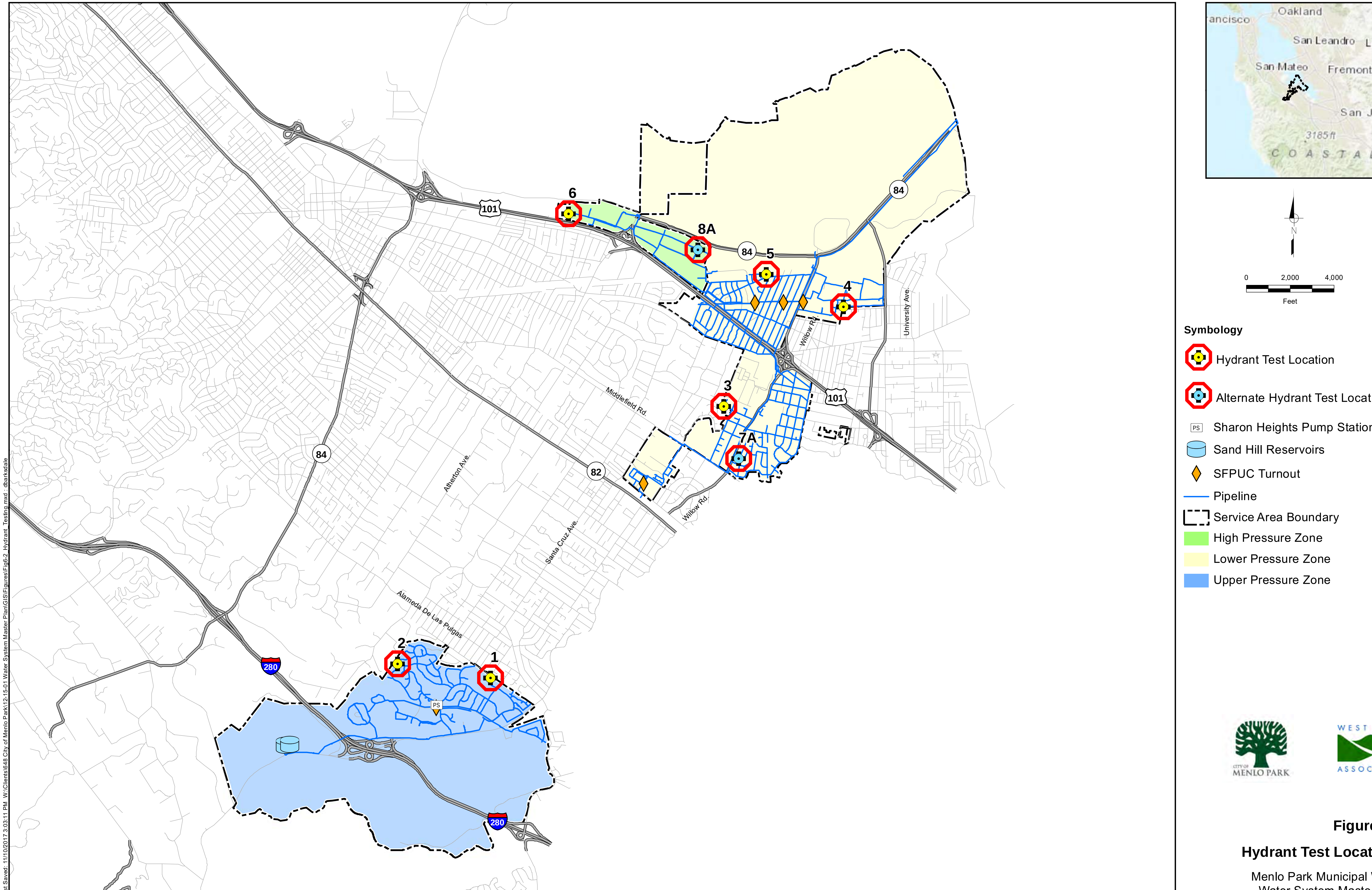

CITY OF MENLO PARK

WEST YOST ASSOCIATES

Figure 6-2

Hydrant Test Locations

Menlo Park Municipal Water
Water System Master Plan

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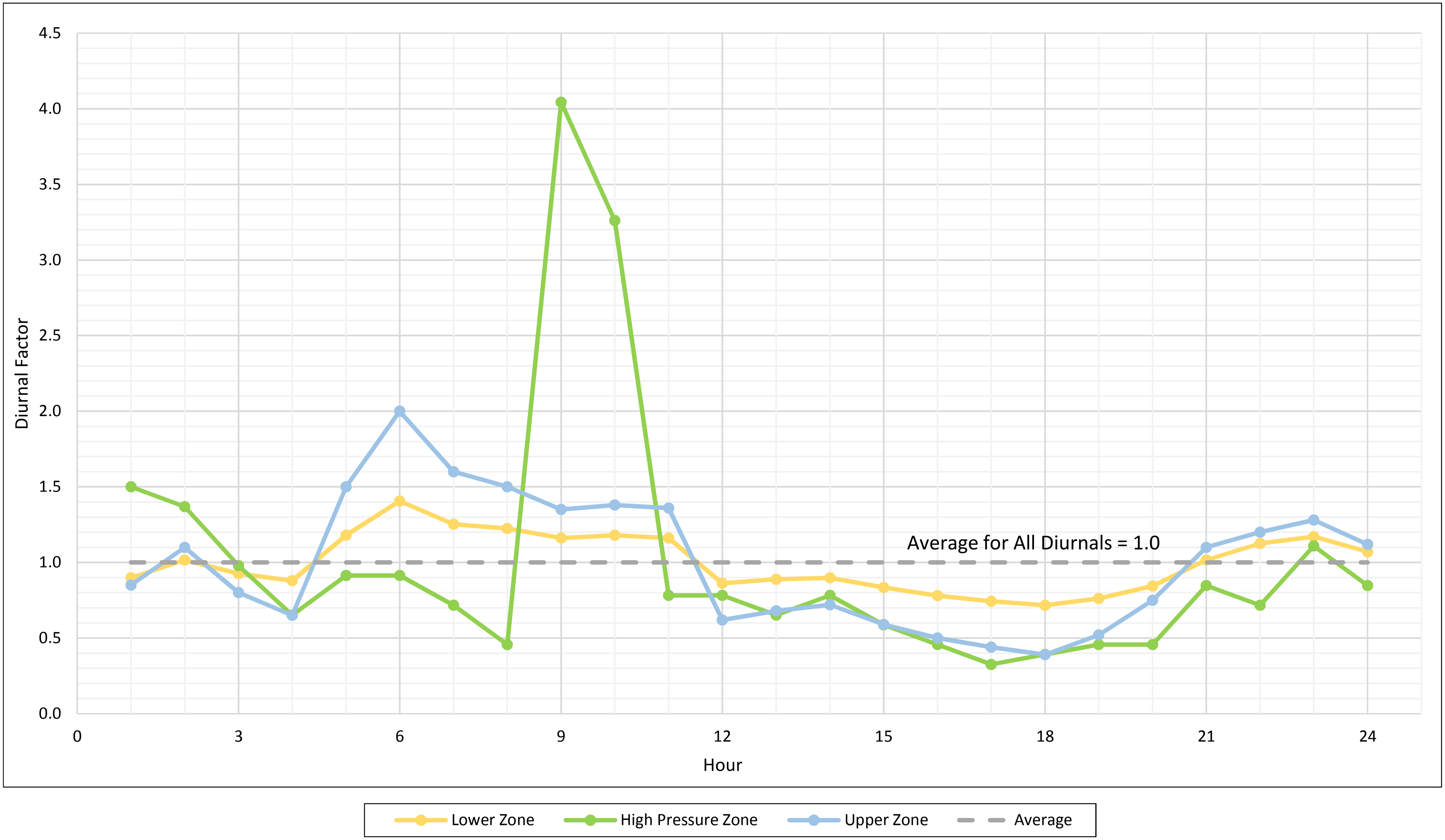

Notes:

1. Based on data from SFPUC Turnouts for 2016, provided by MPMW.
2. Upper Zone Diurnal based on Lower Zone Diurnal, with Peak Hour Peaking Factor of 2.0.

Figure 6-3

Summary of Diurnal Water Demand Patterns

Menlo Park Municipal Water
Water System Master Plan

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Existing Water System Evaluation

This chapter presents the evaluation of MPMW's existing water distribution system, as shown on Figure 7-1, and its ability to meet the recommended planning and design criteria under existing water demand conditions.

This evaluation includes system capacity and performance evaluations. The system capacity evaluation includes an analysis of pumping/supply and water storage capacity. The system performance evaluation assesses the existing water system's ability to meet recommended planning and design criteria under normal (peak hour demand conditions) or fire flow (existing maximum day or peak hour demand plus fire flow). This chapter also summarizes findings from a seismic vulnerability assessment, pipeline condition assessment and advanced metering infrastructure evaluation. West Yost conducted the system performance evaluation using the hydraulic model developed for this WSMP, which is described in Chapter 5.

Deficiencies in the existing water distribution system are identified in this chapter. Improvement recommendations for the system capacity and performance evaluations are detailed in Chapter 8, since sizing for these improvements is based on future demand conditions. Improvements for other programs are summarized in this chapter. Recommendations were used to develop a capital improvement program, which is described in Chapter 9.

The following sections present the evaluation methodology and results from the existing water system evaluation:

- Existing Water Demands
- Existing Water System Facility Capacity Evaluation
- Existing Water System Performance Evaluation
- Seismic Vulnerability Assessment
- Pipeline Condition Assessment
- Advanced Metering Infrastructure Evaluation
- Other Recommended Improvements
- Summary of Findings and Recommendations for the Existing Water System

7.1 EXISTING WATER DEMANDS BY PRESSURE ZONE

Table 7-1 summarizes existing water demands by pressure zone. Existing water demands for MPMW's water system were spatially located in the hydraulic model using the annual average water consumption data for 2013.[1] The annual average consumption was then scaled to match the water purchased from SFPUC for 2013. Maximum day and Peak Hour Demands were subsequently estimated based on the adopted peaking factors, as described in Chapter 3 (see Table 3-7).

[1] Spatially located 2013 water consumption data was provided by MPMW on 2/6/2017 (2013_MP_Baseline_Data.shp).

Table 7-1. Water Demands, Existing Conditions

Pressure Zone	Average Day Demand[a]		Maximum Day Demand[b]		Peak Hour Demand[c]	
	gpm	mgd	gpm	mgd	gpm	mgd
Lower Zone	1,442	2.1	2,221	3.2	3,124	4.5
High Pressure Zone[d]	188	0.3	290	0.5	408	0.7
Upper Zone	879	1.3	1,671	2.4	3,342	4.8
Total	2,509	3.7	4,182	6.1	6,873	10.0

(a) Average day demand based on 2013 SFPUC deliveries obtained from the Monthly Purchase Spreadsheet received from MPMW.

(b) Maximum day demand is equal to the associated pressure zone peaking factor multiplied by the average day demand, refer to Table 3-7.

(c) Peak Hour demand is equal to the associated pressure zone peaking factor multiplied by the average day demand, refer to Table 3-7

(d) Average day demands in the High Pressure Zone were adjusted to exclude the CalTrans demand (approximately 48 gpm) that was recorded in 2013. A review of 2014 and 2015 data confirmed that this demand no longer exists.

7.2 EXISTING WATER SYSTEM FACILITY CAPACITY EVALUATION

To evaluate the capacity of the existing MPMW water system facilities, the following analyses were conducted:

- Supply Capacity Evaluation; and
- Storage Capacity Evaluation

The results of the existing water facility analyses are discussed below.

7.2.1 Supply Capacity Evaluation

MPMW's supply criterion is described in Chapter 5, and requires MPMW to have sufficient firm supply capacity equal to the Maximum Day Demand in zones with storage and equal to Peak Hour Demand in zones without storage. Firm capacity assumes a reduction in total supply or pumping capacity to account for facilities that are out of service at any given time due to mechanical breakdowns, maintenance, water quality, or other operational issues. At the Sharon Heights booster pump station, firm booster pumping capacity was defined as the total booster pump station capacity with the largest pump out of service. For pressure regulating stations, which are hydraulically actuated and are less prone to mechanical failure, the firm capacity was assumed to equal the total station capacity with all valves in service.

For pressure zones without storage that are supplied solely by turnouts (*i.e.,* High Pressure Zone) or PRV stations (*i.e.,* Lower Zone), the supply capacity criterion requires MPMW's water system to have sufficient firm supply capacity to meet peak hour demands for normal operating conditions and peak hour demands plus fire flow for fire flow conditions. For pressures zones with storage (*i.e.,* Upper Zone), Peak Hour and Maximum Day plus Fire Flow demands are met from a combination of zone supply and storage. The firm supply capacity under this condition must be equal to or exceed the Maximum Day Demand.

Table 7-2 compares the existing firm supply capacity with the required firm supply capacity for existing demand conditions. The left-hand side of the table shows the pressure zones, available supply facilities, and the associated capacities for each of the facilities. The right-hand side of the table shows the existing total and firm supply capacities, the required firm supply capacity based on the supply capacity criterion, and the difference between the existing firm supply capacity and the required firm supply capacity. It should be noted that the required supply criterion assumes non-sprinklered conditions for the largest fire flow, based on land use within the pressure zone.

As summarized on Table 7-2, the Lower Zone and Upper Zone have surplus supply capacities of approximately 580 and 1,130 gpm respectively. Based on the criterion listed in Chapter 5, the High Pressure Zone supply capacity is limited to 4,230 gpm, which is calculated as the maximum flow rate with a 12 feet per second flow velocity constraint through a 12-inch diameter pipeline. The High Pressure Zone has a supply capacity deficit of approximately 4,180 gpm assuming the above described criterion. However, this supply capacity deficit would only need to be addressed if the hydraulic evaluation shows that sufficient flow cannot be provided to the pressure zone to meet fire flow conditions. The hydraulic analysis discussed in Section 7.3.2 did not show a constraint and fire flows within the High Pressure Zone can be supplied with sufficient residual pressure at most locations, so no improvement is recommended. Locations that did not meet fire flow requirements are confined to areas where there are single feeds to an area that have small diameter pipelines serving them. Improvements to these areas are recommended and discussed in more detail in subsequent sections.

The Sharon Heights BPS is the sole source of supply to the Upper Zone, and therefore is defined as a critical facility requiring onsite backup power, per the criteria established in Chapter 5. The pump station already has backup power, so no improvement is required.

In recent years, the Lower Zone has been predominantly supplied by the Burgess PRV station, as summarized on Table 7-3. As shown on Table 7-3, the Burgess regulating station supplied between 59 to 95 percent of the total Lower Zone demand since 2011. However, prior to 2011, supply to the Lower Zone was more evenly distributed between the three PRV stations. MPMW Operations Staff reported that higher pressures from the Madera and Chilco PRV stations have caused relief valves to activate and have caused various buildings and residences within the vicinity of the Bayfront Area to flood. As a result, the Chilco and Madera PRV stations were adjusted (around 2010/2011) to lower pressure setpoints, but still be available to supplement the Burgess PRV station during peak demands, fire flow and emergency events. This is graphically illustrated on Figure 2-3, which shows the Burgess PRV station having an HGL of 213 feet msl, compared to the Madera and Chilco PRV stations being set at an HGL of 163 and 161 feet msl, respectively.

Table 7-2. Comparison of Available and Required Supply Capacity, Existing Conditions

Pressure Zone	Supply Sources		Supply Capacity[a]	Existing Firm Supply Capacity, gpm	Required Firm Supply Capacity[b], gpm		Firm Supply Capacity Surplus (Deficit), gpm
Lower Zone	Chilco Pressure Regulating Station	8-inch PRV	3,100	11,700	Peak Hour + FF	11,124	576
		4-inch PRV	800				
	Madera Regulating Station	8-inch PRV	3,100				
		4-inch PRV	800				
	Burgess Regulating Station	8-inch PRV	3,100				
		4-inch PRV	800				
High Pressure Zone	SFPUC Turnout 13	Open Connection[c]	4,230	4,230	Peak Hour + FF	8,408	(4,178)
Upper Zone	Sharon Heights PS[d]	Pump 1	1,550	2,800	Maximum Day Demand	1,671	1,129
		Pump 2	1,550				
		Pump 3	1,550				

(a) Valve capacities based on intermittent maximum flow capacity for ClaVal model 90-01 (100-01 Hytrol internal port). However actual flow capacity will vary based on system conditions.

(b) Zones with storage have a required firm supply capacity equal to the maximum day demand. Zones without storage have a required firm supply capacity equal to the peak hour demand plus fire flow. Fire flow based on largest fire flow requirement (see Table 5-2) in the pressure zone and assumed to be unsprinklered for planning purposes.

(c) High Pressure Zone supplied directly from SFPUC via Turnout 13 and is not regulated. Supply capacity was limited to 4,230 gpm based on a recommended maximum velocity of 12 feet/sec, during fire flow conditions. However, the hydraulic evaluation indicates that fire flows can still be met at sufficient residual pressures at most locations, therefore no improvements are recommended.

(d) Firm capacity at Sharon Heights PS is defined as the total capacity of all pumps, minus the capacity of the largest pumping unit. However, based on MPMW the actual firm capacity, based on performance testing, is equal to 2,800 gpm.

Table 7-3. Summary of Lower Zone Annual Supply Totals from 2010 to 2011[a]

Year	Total Annual Supply, MG			% of Total		
	Burgess	Madera	Chilco	Burgess	Madera	Chilco
2009	193	221	188	32%	37%	31%
2010	90	217	226	17%	41%	42%
2011	461	15	42	89%	3%	8%
2012	438	90	104	69%	14%	16%
2013	448	197	113	59%	26%	15%
2014	430	31	1	93%	7%	0%
2015	438	22	0	95%	5%	0%

[a] Based on historical deliveries. Obtained from the Monthly Purchase Spreadsheet received from MPMW.

To more equally balance the supply contributions across the three Lower Zone regulating stations and to reduce the dependence of the Burgess regulating station, a Residential/Commercial Pressure Regulator Program is recommended. The program will retrofit customer services in the Lower Zone with individual PRVs, so that settings at the Chilco and Madera PRV stations can be adjusted to more closely match the Burgess PRV station and so that customer relief valves are not activated causing flooding. Approximately 1,800 connections in the Bayfront Area of the Lower Zone would need to be retrofitted with individual PRVs. This value was estimated based on service locations with pressures exceeding 80 psi under static conditions (based on a 213 ft HGL from the Burgess PRV station), or service locations with elevations less than or equal to 28 ft msl.

7.2.2 Storage Capacity Evaluation

The principal advantages that storage provides for the water system are to provide: operational storage to balance differences in demands and supplies; emergency storage in case of supply failure; and water to fight fires. The District's water storage capacity requirement is to provide an operational storage component equal to 25 percent of maximum day demand, an emergency storage component equal to 50 percent of maximum day demand, and a fire flow storage component equal to the highest fire flow multiplied by the recommended duration.

Table 7-4 compares the District's available water storage capacity with the required storage capacity by pressure zone. Existing storage capacities reported in the table are based on nominal storage capacities calculated from tank geometry. The Lower Pressure Zone is assumed to have an Emergency Groundwater Storage Credit of 1.60 MG. The comparison between the District's available and required storage capacities indicates that there is an existing water storage capacity deficit of approximately 2.72 MG in the Lower Pressure Zone and 2.31 MG in the High Pressure Zone. The Upper Pressure Zone has an existing water storage capacity surplus of approximately 1.78 MG.

Table 7-4. Comparison of Available and Required Storage Capacity, Existing Conditions

[A]	[B]	[C]	[D]	[E]	[F] = [D]+[E]	[G]	[H]	[I]	[J] = [G] + [H] + [I]	[K] = [F] - [J]
		Available Storage Capacity, MG				Required Storage Capacity, MG				
Pressure Zone	Maximum Day Demand, mgd	Facility	Storage Capacity	Emergency Groundwater Storage Credit	Total Available Storage Capacity	Operational[a]	Emergency[b]	Fire Flow[c]	Total Required Storage Capacity	Storage Capacity Surplus (Deficit), MG
Lower Zone	3.2	*Emergency Groundwater Well* [d]	0.00	1.60	1.60	0.80	1.60	1.92	4.32	(2.72)
High Pressure Zone	0.5	--	0.00	0.00	0.00	0.13	0.26	1.92	2.31	(2.31)
Upper Zone	2.4	Sand Hill Reservoirs	5.50	0.00	5.50	0.60	1.20	1.92	3.72	1.78

(a) Operational storage is 25 percent of the maximum day demand (See Chapter 5, Table 5-1).
(b) Emergency storage is 50 percent of the maximum day demand (See Chapter 5, Table 5-1).
(c) Fire flow in zones with commercial, industrial, or institutional/governmental customers is 8,000 gpm for 4 hours. Assumed to be unsprinklered for planning purposes (See Chapter 5, Table 5-2).
(d) Groundwater Storage Credit is based on the total volume produced from the planned Emergency Groundwater Well for one day (See Chapter 5, Section 5.4.2.4).
A production capacity of 1,500 gpm is used as confirmed by tests on the City's recently completed emergency well.

7.3 EXISTING WATER SYSTEM PERFORMANCE EVALUATION

This section discusses the hydraulic performance evaluation of the existing water distribution system. The following evaluations were performed to assess distribution system performance under existing water demand conditions:

- Normal Operating Conditions – Peak Hour Demand Scenario: This scenario evaluates customer service pressures in the system during a peak hour demand condition.
- Fire Flow Conditions – Maximum Day Demand plus Fire Flow/Peak Hour Demand plus Fire Flow Scenario: This scenario evaluates fire flow availability in the system under a maximum day demand condition in the Upper Zone and under a peak hour demand condition in the Lower and High Pressure Zones.

These two scenarios use the hydraulic model developed for the WSMP to evaluate the existing water system performance. The existing water system is expected to deliver peak hour flow and maximum day or peak hour demand plus fire flow within the acceptable pressure, velocity and head loss ranges as identified in the planning and design criteria presented in Chapter 5.

7.3.1 Normal Operating Conditions

A steady-state hydraulic analysis was conducted using the hydraulic model to evaluate system performance under an existing peak hour demand condition. As shown in Table 7-1, the peak hour demand for the existing water service area was calculated to be 6,873 gpm (10.0 mgd). This analysis assumed that the Sand Hill Reservoirs are 75 percent full and the Sharon Heights Pump Station is off.

During a peak hour demand scenario, a minimum pressure of 40 psi must be maintained at service connections throughout the entire water system. In addition, for pipelines, it is recommended that maximum velocities should not exceed 4 ft/s in transmission pipelines or 5 ft/s in distribution pipelines during normal demand conditions, to help minimize energy (pumping) costs and excessive head loss due to undersized pipelines.

Results from the peak hour demand simulation indicate that the existing water system could adequately meet the District's minimum pressure criterion of 40 psi at all customer services, except for the locations shown in red on Figures 7-2A and 7-2B.

In the Upper Zone, low pressures occur immediately downstream of the Sand Hill Reservoir where service elevations are within approximately 100 feet of the elevation of the water surface in the Sand Hill Reservoirs. The SLAC has a turnout on the reservoir outlet pipeline that includes a booster pump to provide flow at adequate pressure. All other locations in the Upper Zone range from 40 psi to 120 psi, depending on location and elevation. Since customer demands can be met with adequate pressure, no improvements are required.

Additionally, there were also some pipelines that exceeded the velocity criterion of 4 ft/s in transmission pipelines and 5 ft/s in distribution pipelines. Because pipeline velocity is a secondary criterion, no improvements for pipelines exceeding the velocity criteria in the existing water system are recommended unless the primary criterion (pressure) is not met. A review of these pipelines indicated they are not in the vicinity of low system pressures. Therefore, no mitigation is recommended.

7.3.2 Fire Flow Conditions

A system's ability to provide fire flow is an important consideration for the Insurance Services Office (ISO), the agency that helps to establish fire insurance premiums. ISO uses Public Protection Classification (PPC) scores for communities based, in part, on the community's water system's ability to provide fire flow. ISO rates systems with a PPC score of 1 to 10, with 1 being the highest rating. PPC scores depend on a community's fire alarm and communication systems, fire department readiness and response, and the water supply system, including condition and maintenance of hydrants, and the amount of water available for fires (ISO, 2017). Menlo Park Fire District has a current PPC score of 2 (Menlo Park Fire District, 2017).

To evaluate the existing water system for fire flow conditions, InfoWater's "*Available Fire Flow Analysis*" tool was used to determine the available fire flow at a minimum residual pressure of 20 psi. For the existing system fire flow analysis, key junctions that represent hydrant locations were evaluated to determine the available flow that can be provided, in addition to meeting the maximum day demand. This analysis assumed that the Sand Hill Reservoirs are 75 percent full and the Sharon Heights Pump Station is off.

Figures 7-3A, 7-3B, 7-3C, and 7-3D summarize the available fire flow at each tested hydrant location while meeting the minimum residual pressure criterion of 20 psi. Figures 7-3A and 7-3B show results for the system with fire flow criteria based on non-sprinklered services. Non-sprinklered fire flow requirements range from 1000 gpm for single-family residential to 8000 gpm for multi-family residential, CII uses. Figures 7-3C and 7-3D present results with fire flow criteria based on sprinklered services. For customers with sprinklers, fire flow requirements are 50 percent of non-sprinklered requirements. On each of the figures, locations that meet the fire flow requirements are shown with a green dot. Locations that don't meet fire flow requirements are shown with a red dot. Available fire flow, in gpm, is also noted for locations that are less than fire flow requirements. Results presented in the figures are representative of the system capacity and do not represent available flow from a specific hydrant. Typically, fire flows exceeding 1,500 gpm are met by multiple hydrants.

Figure 7-3A and 7-3B indicate that there are numerous locations that don't meet the non-sprinklered fire flow criteria. These tend to be in locations where there are higher fire flow requirements and hydraulic constraints due to small-diameter pipelines, and/or areas where elevations are higher and static pressures are lower. Figures 7-3C and 7-3D show that the majority of locations meet sprinklered fire flow requirements. For the Lower and High Pressure Zones (Figure 7-3C), deficient areas are confined to areas where there are single feeds to an area, and the O'Brien Drive area in the Lower Zone, east of Willow Road, where there are small diameter pipelines supplying the area that constrain flow to the area. For the Upper Zone, there are a few locations, generally on dead-end pipelines, where fire flows slightly less than the 4,000 gpm criterion for multi-family residential, CII land use.

Fire flow improvements are presented in *Chapter 8* Future System Analysis, since they are sized to meet existing and future conditions.

7.4 SEISMIC VULNERABILITY ASSESSMENT

MPMW is in a highly seismic area being located within one and one-half miles from the San Andreas Fault and 13 miles from the Hayward Fault. Ballantyne Consulting was retained as part of the WSMP to assess the vulnerability of the water distribution system and propose mitigation measures. The seismic vulnerability assessment scope of work included the following:

- Meet with MPMW to review seismic-related issues
- Review relevant documents, including the 2004 Seismic Vulnerability Assessment and 2009 Emergency Response Plan (ERD)
- Conduct a site visit to perform a visual assessment of key water system facilities
- Prepare a pipeline vulnerability assessment to estimate vulnerability during specific earthquake events
- Document findings in a report

This section summarizes the study, which is included in Appendix C.

Since completion of the 2004 Seismic Vulnerability Assessment, MPMW has implemented several recommendations including: replacement of the Sharon Heights Pump Station, replacement of approximately 20,000 feet of pipe (an average of 1,500 feet/year, or about 0.5 percent of the pipeline system annually), and as part of this report, and is conducting a more detailed pipeline seismic vulnerability analysis. MPMW is also implementing an Emergency Water Supply Program to construct three wells for emergency use. The first well will be completed by the end of 2018. In that time, the SFPUC has also conducted its $4.8 billion WSIP, improving the reliability of the RWS that supplies the MPMW. The SFPUC's performance criterion is to deliver average winter-month usage within 24 hours following any earthquake.

The Upper Zone is, for the most part, on competent (non-liquefiable) soils, but because of its proximity to the San Andreas Fault, can expect very strong ground motions in a San Andreas earthquake. The Lower Zone and High Pressure Zone are in areas mapped as having moderate to high liquefaction susceptibility.

A pipeline vulnerability assessment was conducted considering earthquake shaking intensity and liquefaction and associated lateral spread. In the Upper Zone, there is one small area mapped as being liquefiable. It is recommended that the liquefaction probability be quantified, and based on the results, the pipeline passing through that area be replaced with a seismic resistant pipe. In the high-level pipeline assessment, it was estimated that there would be approximately two pipeline breaks and two pipeline leaks in the Upper Zone. It is estimated that with those pipeline failures it would take thirteen hours to drain the reservoirs if they were full at the time of the event. With that much time, MPMW staff should be able to isolate one of the reservoirs to keep some water available for an emergency supply.

Much of the Lower Zone and High Pressure Zone are constructed on liquefiable soils. Most types of existing pipe do not perform well in earthquakes in liquefiable soils. In a San Andreas magnitude 7.9 earthquake, an estimated 97 pipeline failures (22 leaks, 75 breaks) would occur, and in a Hayward magnitude 7.1 earthquake, an estimated 32 pipeline failures (7 leaks, 25 breaks) would occur. These zones are totally dependent on supply from the SFPUC. The pipeline damage is estimated to be so extreme that it is unlikely the supply can keep up, and the system will lose pressure. To mitigate that damage, it is recommended that MPMW place a high priority on replacement of approximately 50,000 feet of pipe with seismic resistant pipe (shown as red and orange colored pipelines on Figure 7-4, which shows estimated pipeline leaks and breaks per 1000 feet of pipeline). The initial focus for pipe replacement should be on CIP, AC, PVC and unknown pipe materials in high liquefaction zone areas. For larger-diameter pipeline that are more critical, recommended pipeline material and construction methods include steel with butt-welded joints, DIP with earthquake resistant joints, molecularly oriented PVC pipe (PVCO) with seismic retrained joints, and HPDE pipe. Of these materials, steel and DIP only considered in soils with low corrosivity. For smaller-diameter, less critical pipelines, recommendations include steel pipe with lap or butt-welded joints, DIP with mechanically restrained joints, and PVCO pipe with double-depth bells. Recommended pipeline materials by zone are summarized in Table 7-5.

High-priority pipeline replacements are addressed in the Pipeline Condition Assessment task, discussed in Section 7.5.

Other recommendations from the Seismic Vulnerability Assessment include:

- Perform a more comprehensive hazard review, including field survey of geologic conditions along critical pipeline alignments, review of boreholes, update of liquefaction and landslide models.
- Update the pipeline analysis prepared in this study based on a more comprehensive hazard review.
- Conduct both a geotechnical and structural assessment for the two Sand Hill Reservoirs to assess their capabilities to withstand the scenario earthquakes. There is no record of previous assessments performed as part of the original design or thereafter, and code requirements have become more stringent since Reservoir No. 2 (the newer) was constructed in the 1990s.
- Upgrade wood roofs on Sand Hill Reservoirs. Implement geotechnical mitigation. Identify specific improvements based on the findings of the geotechnical and structural assessment.
- Conduct a detailed evaluation of the Maintenance Building to assess condition and retrofit needs.
- Implement a non-structural anchorage program as part of the regular maintenance budget.
- Update MPMW's ERD with an Earthquake Annex and an Earthquake Recovery Plan developed that will provide direction to optimally restore the system.

Table 7-5. Recommended Pipeline Materials Considering Criticality, Ground Motion, Liquefaction/Peak Ground Deformation, and Soil Corrosivity

Pressure Zone	Criticality	Ground Motion	Liquefaction Zone	Peak Ground Deformation	Corrosivity	Recommended Pipe System
Upper Zone	High	Very Strong	None	None	Low	Steel with butt welded joints, DIP with earthquake resistant joints, PVCO with seismic restrained joints, HDPE
Upper Zone	Moderate	Very Strong	None	None	Low	Steel with lap welded joints, DIP with mechanical restrained joints (not wedges), PVCO with double depth bell, HDPE
Lower Zone	High	Strong	High	>4"	Low	Steel with butt welded joints, DIP with earthquake resistant joints, PVCO with seismic restrained joints, HDPE
Lower Zone	Moderate	Strong	High	>4"	Low	Steel with lap welded joints, DIP with mechanically joints, PVCO with double depth bell, HDPE
Lower Zone	High	Strong	High	>4"	Yes	PVCO with seismic restrained joints, HDPE
Lower Zone	Moderate	Strong	High	>4"	Yes	PVCO with seismic restrained joints, HDPE
Lower Zone	High	Strong	Moderate	<4"	Yes	PVCO with seismic restrained joints, HDPE
Lower Zone	Moderate	Strong	Moderate	<4"	Yes	PVCO with double depth bell, HDPE

Notes:
Criticality: high – backbone, transmission, large diameter; moderate - smaller diameter residential/commercial. More reliable pipe is selected for high criticality demands.
Ground motion: very strong – Peak Ground Velocity (PGV) >24 in/sec; strong <= 24 in/sec
Earthquake resistant joints – restrained but allow longitudinal movement
Mechanical restrained joints – requires locking ring, gaskets with wedges not allowed
PVCO – Molecularly oriented PVC AWWA C-909
Double depth bell – accommodates 2X extension before failure

- Acquire emergency generators and portable pumps. Develop specific recommendations in operational and recovery plans.[2] Develop a plan and acquire required equipment for fueling emergency generators following an earthquake.
- Develop a seismic design procedure manual for new pipelines and tanks. ASCE is developing a manual of practice for seismic design of water and sewer pipelines that may fulfill this requirement. MPMW designs very few new tanks. Review seismic design criteria for new tanks.

7.5 PIPELINE CONDITION ASSESSMENT

To develop a long-term pipeline rehabilitation/replacement (rehab/replacement) plan for MPMW, a risk assessment was performed to prioritize pipelines with the highest risk of failure for replacement. This section describes the failure analysis research, the risk assessment methodology used, and the resulting proposed pipeline rehab/replacement strategy.

7.5.1 Pipeline Asset Inventory

The City's existing pipeline asset inventory information serves as the foundation of this assessment, upon which other factors are built. The more complete and accurate the inventory, the more accurate the results of the risk model are.

Pipeline material and diameter are recorded in MPMW's GIS inventory for over 90 percent of the system, by length. Pipeline installation year, however, is recorded for only 32 percent of the pipes. The following methodology was used to fill asset inventory gaps described above:

- **Pipeline Installation Year**: Where possible, pipeline installation year was updated based on available record drawings or housing construction dates, which is estimated to have a higher level of accuracy[3]. Next, the installation year gaps were approximated using nearby hydrant casting dates, or connecting water main installation dates, all of which were estimated to the closest decade and have a medium accuracy level. Lower accuracy assumptions were made for the remaining pipelines using near-by water main installation years.
- **Pipe Material and Diameter**: Where possible, pipeline material and/or diameters were updated according to the limited amount of record drawings available.

[2] Per discussions with MPMW, key facilities have generators, including the Administration Building, Sharon Heights Pump Station and the emergency well. Therefore, no capital project has been included for this recommendation.
[3] Housing construction dates were estimated by using Zillow.com as a reference.

Table 7-6 summarizes the results of the asset inventory improvements for pipeline installation year.

Table 7-6. Water Main Installation Year Approximation Results

Installation Year	Total Length of Pipelines, Linear Feet (LF)			Total Pipeline Length, LF	% of Total
	High Accuracy	Medium Accuracy	Low Accuracy		
1940	6,560	3,990	-	10,550	4%
1950	3,066	11,976	4,619	19,661	7%
1960	15,074	29,313	8,384	52,771	18%
1970	29,370	11,397	4,121	44,887	15%
1980	51,208	13,650	4,715	69,573	24%
1990	12,437	7,030	5,290	24,758	9%
2000	26,036	8,464	7,177	41,677	14%
2010	9,317	15,522	1,390	26,229	9%
Total	**153,068**	**101,341**	**35,696**	**290,105**	**100%**
% of Total	53%	35%	12%	-	-

7.5.2 AC Pipe Failures

MPMW is particularly concerned with the life expectancy of the large amount of aging AC pipeline in its distribution system. West Yost reviewed the findings of AC pipeline failure analysis studies published by water sector agencies and the Water Research Foundation (WRF). These industry studies have found:

- Pipeline deterioration, like other corrosion processes, slows over time.
- Break history is the best predictor of break likelihood.

Additional factors that correlate to failure rates include:

- Installation era: for many pipeline materials, pipelines installed before 1950 have higher failure rates. But the installation eras after 1950 tend to perform the same, and not correlate to age.
- Higher pressures can act as stress cycles and take their toll on older pipelines.
- High soil linear extensibility (shrink/swell rate) is another stress cycle that increases failure rates.

Field testing that was *not* found useful in predicting AC pipe failures include:

- AC pipeline external strain loss cannot be correlated with calcium or crushing strength loss.
- Sulfate, pH and other soil chemistry testing cannot directly be used to predict failure rates.
- Ground slope appears to have little correlation.

7.5.3 Failure Analysis

The risk assessment evaluates the likelihood and consequence of a pipeline failure. For this analysis, a pipeline failure is considered to be a structural failure that causes a water main leak/break. Pipeline leaks/breaks must be isolated, dewatered, and disinfected as part of the repair process, and thus cause water service outages to customers. Leaks/breaks can also require costly emergency repairs which are disruptive to the community.

Other principal failure mechanisms for pipelines such as hydraulic capacity and water quality failures are addressed elsewhere in this WSMP, and are, therefore, not included in this analysis. However, results from the seismic vulnerability assessment are included in this analysis.

7.5.3.1 Risk Assessment Methodology

The likelihood of failure analysis assesses the probability that a failure will occur. The consequence of failure considers the impact a failure may have on MPMW and its customers. A rating for both likelihood and consequence of failure was assigned in a risk model for each pipeline. The risk assessment model then combined the likelihood of failure ratings with the consequence of failure ratings to develop a comprehensive risk rating. The sections below summarize the MPMW-specific analysis that used available information to assign a risk level for each pipeline.

7.5.3.2 Likelihood of Failure

The likelihood of failure analysis considers the probability that a failure will occur in a given water main. The following factors are considered in determining the likelihood of a structural failure:

- **Physical Mortality**: As infrastructure ages, its physical condition deteriorates. Pipeline installation year is used to approximate the remaining useful life of each pipeline (see Figure 7-5). For many pipeline materials, pipelines installed before 1950 have higher failure rates due to the limits of manufacturing processes before 1950, therefore, these pipelines will have elevated failure likelihoods.
- **Break History**: Based on our review of published pipeline failure studies, leak/break history is the best predictor of break likelihood. The only leak/break records available for the City are for the past two years (see Figure 7-6). This data, while limited, is still the most valuable indicator of increased likelihood of failure.

- **Seismic Ground Shaking**: Some pipelines are more likely to fail than others in the event of an earthquake. The San Andreas liquefaction scenario leak and break results from the Seismic Vulnerability Assessment discussed earlier in this chapter were used for this factor (see Figure 7-4).
- **Exterior Corrosion**: Exterior corrosion of the pipeline at the pipe/soil interface increases the likelihood of failure. While records were not available for the presence or condition of exterior pipeline wraps or coatings to protect against corrosive soils, the general assumption can be made that concrete pipelines in soil highly susceptible to concrete corrosion are generally more likely to sustain exterior corrosion than pipelines in non-corrosive soils. Soil corrosivity data from the USDA Natural Resources Conservation Service was used to approximate this factor, as shown in Figures 7-7 and 7-8.
- **Stress/Strain**: As found in our review of published pipeline failure studies, higher working pressures can act as stress cycles and cause higher failure rates in older pipelines. Therefore, the average day system working pressure results from the hydraulic analysis performed for this WSMP were used for this factor (shown in Figure 7-9).

The risk model was applied to each pipeline to produce a single rating for each of the five likelihood failure factors listed above on a scale of one to five, with five being the highest possible (worst) rating. Ratings were assigned to each pipeline using the rating basis summarized in Table 7-7. The model calculated the weighted total of the five scores as the single Likelihood of Failure rating.

7.5.3.3 Consequence of Failure

The consequence of failure considers the potential impacts from a main break in each segment of the system. For this analysis, the following potential consequences were considered:

- **Reduced Level of Service (LOS)**: Water service outage, service outage to critical customers (hospitals, schools, and large water users).
- **Public Impacts**: Increased traffic due to construction.
- **Fiscal Impacts**: Emergency pipeline repair costs.
- **Environmental Impacts**: Chlorinated water discharge to waterways.

Table 7-7. Likelihood of Pipeline Failure Rating Factors

Category	Factor	Rating (1 being the lowest, 5 being the highest) 1	2	3	4	5	Scoring Logic	
Primary Rating Factors								
Physical Mortality	Installation Year	Post-1990	Between 1980-1989	Between 1970-1979	Between 1960-1969	Pre-1959	*Primary Rating: Maximum of Two Rating Values*	
Break History	Leak/Break History	Single Service Line Leak	Multiple Service Line Leaks	Main Appurtenance Leak	Single Main Leak	Multiple Main Leaks		
Rating Adjustment Factors								
Seismic Ground Shaking	Pipeline Repair Rates per Seismic Vulnerability Assessment	≤0.13	0.14-0.36	0.37-0.46	0.47-0.59	≥0.60	*If Primary Rating = 1, AND Maximum of Three Rating Adjustment Factors > 3*	*+1*
Exterior Corrosion	Soil Corrosivity Data and Pipeline Material	Located in Soil with Low Corrosion Susceptibility	Located in Soil with Moderate Corrosion Susceptibility	Located in Soil with High Corrosion Susceptibility	-	-	*If Primary Rating > 1, AND Maximum of Three Rating Adjustment Factors > Primary Rating*	*+1*
Stress/Strain	System Working Pressure	≤60 psi	61-79 psi	80-99 psi	100-119 psi	≥120 psi		
				Total Likelihood of Failure Score:	**Sum of Primary Rating Factors and Adjustment Factors - Up to a Maximum Score of 5**			

Upon analysis, it was found that pipeline diameter (shown on Figure 7-10) was a nearly complete proxy for all of the factors listed above:

- Reduced LOS:
  - **Water Service Outage**: Due to the reduced supply capacity, the size and impact of an outage from a pipeline break generally grows proportionally to the diameter of the pipeline. The other factor influencing the impact of an outage is redundancy. There are two primary pipelines that are not looped for redundancy, and would, therefore, have more significant consequences if these pipelines were to fail. These two pipelines are: 1) the inlet/outlet pipeline from the Sand Hill Reservoirs, which would require Sharon Heights Pump Station to supply the zone, without a reliable means to control pressure; and, 2) the pipeline in Middlefield Road, downstream of the Burgess Turnout, which would require supplying the zone from other turnouts at reduced pressure. For this factor, pipeline diameter was used, and the two non-looped pipelines were elevated to critical levels.
  - **Service Outage to Critical Customers**: The Veterans hospital, all but one of the schools (the Philip Brooks School), and the largest water users (the SLAC Laboratory, the Veterans hospital, Facebook, and SRI International) were located along large-diameter (≥ 10-inches) pipelines. Therefore, pipe diameter was used as a proxy for this factor as well.
- **Fiscal Impacts**: Barring outside cost escalation factors that are not able to be modeled with available data, emergency pipeline repair costs escalate as pipeline diameter increases. Therefore, pipeline diameter was used as a proxy for emergency repair costs.
- **Environmental Impacts**: San Francisquito Creek and the Atherton Channel are the only open-channel waterways in the service area. Both discharge to San Francisco Bay. The impact to the creeks depends on the drainage system. For example, a large section of the Willows neighborhood drains away from nearby San Francisquito Creek and discharges to San Francisco Bay. The San Francisquito Creek borders a single street, Woodland Avenue for approximately 0.7 miles from Middlefield Road to Menalto Avenue. The risk level of the pipelines in this segment of Woodland Ave will be elevated for the risk of discharge to a waterway.
- **Public Impacts**: The City street classification layer was used to evaluate increased traffic due to construction.

Each pipeline is rated by the model for each consequence of failure factor on a scale of one to five, with five indicating the highest adverse consequence of failure. Ratings were assigned to each pipeline using the rating basis summarized in Table 7-8. The model calculated the weighted total of the ratings for each category as the single Consequence of Failure.

Table 7-8. Consequence of Pipeline Failure Rating Factors

Category	Factor	Rating (1 being the lowest, 5 being the highest)					Scoring Logic
		1	2	3	4	5	
Primary Rating Factors							
Fiscal Impacts Service Outage to Critical Customers Emergency Repair Costs Water Service Outage	Pipeline Diameter	< 8-inch	8-inch	10-inch	12-inch	≥ 14-inch	*Single Rating*
Rating Adjustment Factors							
Water Service Outage	Non-Looped Pipes						*+2*
Environmental Impacts	Woodland Avenue						*+1*
Public Impacts	Collector/Arterial Street						*+1*
	Railroad or Highway Crossing						*+2*
Total Consequence of Failure Score	**Sum of all Primary Raiting Factors and Rating Adjustment Factors - Up to a Maximum Score of 5**						

7.5.3.4 Risk Assessment Results

The risk model applies a series of algorithms to generate the total likelihood and consequence of failure score for each pipeline, as described above. By plotting the consequence of failure and the likelihood of failure scores against each other, an overall risk level was assigned to each pipeline. Risk was prioritized into five levels: High Risk, Medium-High Risk, Medium Risk, Medium-Low Risk, and Low Risk, as shown in Table 7-9. These risk levels are assigned to the various ranges using best engineering judgment to determine which combinations of scores warrant the highest level of concern versus those that warrant lesser levels of concern. The overall risk score is determined by multiplying the Consequence of Failure and Likelihood of Failure Scores. Pipelines with an overall risk score of 15 or greater, for example, are considered high risk. Table 7-9 shows the linear footage of water mains (with a system total of 290,105 LF) that fall into each risk range. These risk assessment results are shown graphically on Figure 7-11.

Table 7-9. Risk Assessment Results

LF of Pipelines		Likelihood of Failure					
		1	2	3	4	5	Total
Consequence of Failure	1	12,530	27,173	29,862	8,459	15,159	93,183
	2	20,015	25,374	28,581	9,493	10,085	93,548
	3	5,196	8,371	7,360	8,073	13,159	42,159
	4	7,053	3,371	7,017	7,205	8,992	33,638
	5	10,825	1,552	3,128	6,166	5,906	27,5787
	Total	**55,619**	**65,841**	**75,948**	**39,396**	**53,301**	**290,105**

Risk Levels: Dark Green = Low (Overall Risk Score Less than 3),
Light Green = Medium-Low (Overall Risk Score between 3 and 4),
Yellow = Medium (Overall Risk Score between 5 and 9),
Orange = Medium-High (Overall Risk Score between 10 and 14),
Red = High (Overall Risk Score Greater than 15)

The risk assessment results are summarized in Table 7-10, which lists the total LF of pipelines that fall in each risk level by pressure zone, and also summarizes pipeline lengths for the Bayfront Area, which includes portions of the Lower Zone and High Pressure Zone.

Table 7-10. Summary of Risk Assessment Results					
	Pipeline Length, LF				
Risk Level	Lower Zone (% of Total)	High Pressure Zone (% of Total)	Upper Zone (% of Total)	Total (% of Total)	Bayfront Area[(a)] (% of Total)
Low	47,720 (26%)	35 (1%)	11,961 (15%)	59,716 (21%)	2,115 (4%)
Medium-Low	56,828 (31%)	1,333 (5%)	17,783 (22%)	75,944 (26%)	6,098 (11%)
Medium	50,156 (27%)	4,276 (18%)	21,369 (26%)	75,801 (26%)	22,250 (39%)
Medium-High	17,193 (9%)	2,503 (10%)	14,392 (17%)	34,087 (12%)	8,208 (14%)
High	12,247 (7%)	16,113 (66%)	16,196 (20%)	44,556 (15%)	18,097 (32%)
Total	**184,144**	**24,260**	**81,701**	**290,105**	**56,768**

(a) Includes pipes that are located outside of the Bayfront boundary but are critical for supplying the Bayfront area.

The risk assessment provides a generalized priority for pipeline replacement. MPMW should refine priorities based on more specific needs, such as re-location of pipelines that currently are on private property and/or under existing structures, such as the Burgess Turnout pipelines under the Skate Park and on SRI property, projects that should be coordinated with other projects, such as re-paving projects, etc.

7.5.4 Rehab/Replacement Strategy

MPMW is interested in developing a proactive pipeline replacement program that minimizes unscheduled water outages. This section provides strategy recommendations for a long-term rehab/replacement program for pipelines.

7.5.4.1 High-Risk Priorities

This program specifically focused on reducing failure risk. The risk analysis results presented above should be used to prioritize water mains for replacement – with the high-risk pipelines replaced first.

To minimize construction impacts to the public, it is recommended that MPMW expand this analysis to the city-block level so that small-diameter rehab/replacement projects can be planned to replace the pipeline in the entire residential street.

7.5.4.2 Construction Methods

Pipeline rehabilitation methods such as cast-in-place pipe can reduce the cost per foot of pipe by up to 40 percent in some cases, and can significantly extend the useful life of the existing mains. However, existing failure points such as service taps, service lines, valve connections, and hydrant assemblies typically remain intact. Therefore, full pipeline replacement is recommended by open cut construction or pipe bursting construction methods (bursting AC pipe is not recommended). If MPMW's position changes from proactive to a reactive one with urgency, this strategy should be revisited.

7.5.4.3 Recommendations

Considerations for developing improvement project packages include:

- Plan for rehab/replacement projects of $1.2 million (M) or more (base construction cost, $1.6M with 30 percent contingency). Construction packages of less than $1.0 million are less attractive to contractors, which limits competition and drives unit prices much higher.
- Implement larger-diameter main replacements and capacity improvement projects in construction packages of approximately one-half mile of pipeline per year to allow for project complexities and to reduce traffic impacts in collector and arterial roads.
- As mentioned above, in order to reduce public impacts of small-diameter rehab/replacement projects, replace the pipeline in the entire street.
- Develop a long-term paving and sidewalk repair program so that there is adequate planning time to coordinate paving, sidewalk, water, sewer, and drainage projects to minimize construction impacts on the public – particularly on residential streets and small business frontages.
- Coordinate projects with other City-funded projects, such as street paving projects.
- Prioritize re-location of pipelines on private property to public rights-of-way (e.g., SRI, Facebook Willow Campus, pipeline under Stake Park at Burgess Park).

West Yost recommends funding this program at $1.6 million (M) per year construction costs, including contingency ($2.0M capital costs in current dollars), which over the WSMP timeframe (through 2040), would fund projects in the Medium-High and High-Risk categories. This is about twice the current rate of pipeline replacement funding by MPMW.

7.6 ADVANCED METERING INFRASTRUCTURE EVALUATION

MPMW is considering changing its water meter system from manual meter readers by a private company to an AMR or AMI system. As part of the WSMP, MPMW requested that West Yost summarize and evaluate AMR and AMI options. A copy of the analysis is included as Appendix D, and a summary of the analysis is provided below.

Implementation of an AMR or AMI system will decrease the time for meter data collection and improve the efficiency of billing operations. Both technologies provide the opportunity for increased customer service through more accurate meter reads. AMI also provides utilities with the opportunity to identify water usage trends in ways that are not achievable with monthly or bi-monthly meter readings. Using near real-time data to remotely monitor and manage the water utility infrastructure, utilities with AMI can proactively alert customers of potential leaks or high water usage.

AMR uses radio frequency communication technology or wireless reading probes to read meters without requiring a physical read from the meter or entry into the meter box. Readings are typically collected using walk-by or drive-by data collection devices. AMI builds on AMR infrastructure to remotely monitor and manage the water utility infrastructure. A fixed base antenna collects radio reads, and a data management system is used to store and interpret data.

Both AMR and AMI systems require installation of a transceiver at the meter to transmit the data. MPMW would be interested in a Sensus-based system, since it currently standardizes on Sensus. Approximately one half of MPMW's existing meters would be compatible with AMR or AMI and would not require replacement[4]. An AMR system requires collection devices to collect and store meter data. AMI would require an antenna, base station and software to collect and manage data. The software interfaces with the customer billing system to collect data and transmit information for billing. A propagation study would be required to locate the AMI base stations. Initial investigation indicates that two base stations would likely be required – one for the Lower Zone and High Pressure Zone and one for the Upper Zone.

Many utilities with AMR or AMI have an online interface for customers to view their water use. Some utilities have found that one full-time staff dedicated solely to customer service calls was necessary once they switched to AMI. The increase in customer service calls would be less with AMR, since data reads would only be monthly. Other utilities have found that while there are equipment maintenance requirements, there was no net change in the maintenance time needed to service equipment once staff became familiar with troubleshooting the AMR and AMI equipment issues.

If MPMW elected to install an AMR walk-by system, MPMW could continue to contract with a private company to read the meters, as it does now. For a drive-by or AMI system, it is presumed that MPMW would take on the responsibility of meter reading, and could either implement in-house billing or continue to use a private company to provide billing services. Implementation of AMI or AMR could be completed as a single program or could be phased in over time. For example, the City of Redwood City started implementation of an AMI program starting in 2008 but is phasing it in over time so that meters won't require end-of-life replacement at the same time and in-house staff can be used to convert meters to AMI. As of early 2017, about 60 percent of Redwood City's system was on AMI.

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[4] Based on a conversation with Craig Molaug from Golden State Flow Measurement, $C^{2,}$ OMNI, SR I and SR II meters are compatible with AMR or AMI configuration and were therefore assumed not to need replacement. The above-mentioned models comprise approximately 1,962 of the existing 4,355 meters (roughly half).

A conceptual-level cost estimate for the installation of AMR or AMI found that the capital costs were not significantly different, with an estimated cost of $2.37M for AMR compared with an estimated cost of $2.51M for AMI. The annual costs for the AMI analytical software are higher than the AMR software support ($23,800 per year difference). The capital improvement program presented in Chapter 9 includes a budgetary estimate assuming conversion to AMI.

7.7 OTHER RECOMMENDED IMPROVEMENTS

Over the course of the study, other improvements were identified, either by MPMW, or as part of the different WSMP evaluations. These projects are included to improve system reliability and operational efficiency, and are summarized below:

- **New Emergency Interconnection with Cal Water:** The City of Menlo Park is proposing a new Alma Street elevated pedestrian bridge to cross the CalTrain tracks at Alma Street. West Yost recommends including a new pipeline on the bridge to provide an emergency interconnection to Cal Water as part of this project. This project would require approximately 2,000 feet of 12-inch diameter pipeline and a meter within a vault.
- **New Emergency Interconnection with City of Palo Alto:** The San Francisquito Creek Joint Powers Authority (SFCJPA) is proposing to replace the Pope/Chaucer Street Bridge to improve flood protection. West Yost recommends coordinating with SFCJPA and the City of Palo Alto to include an emergency interconnection to the City of Palo Alto system as part of this project. This would require approximately 250 feet of 12-inch diameter pipeline, and a meter within a vault.
- **Residential/Commercial Pressure Regulator Program:** A project to retrofit customer services in the Lower Zone with individual PRVs is recommended, so that flow from the different PRV stations can be better distributed, and so MPMW is not so reliant on the Burgess PRV, which has a single-feed pipeline to the Lower Zone. Approximately 1,800 connections would need to be retrofitted with individual PRVs. These connections are based on service elevations that are less than 28 feet msl. For the purposes of developing capital improvement program costs, it was assumed that all 1,800 connections would need to be retrofitted. However, MPMW during implementation of this program, MPMW could focus efforts on addressing customers that are predominately affected first, so that PRV settings can be adjusted, and proceeding with the remaining connections as needed.
- **Pressure Monitoring/Reporting at SFPUC Turnouts:** Currently, pressures at SFPUC turnouts are not monitored or recorded by the SCADA system. This project would install pressure monitors and provide remote terminal units at the turnouts for reporting information in SCADA. This would improve system monitoring and assist Operations staff in troubleshooting operational issues associated with turnouts.
- **Continue Backflow Prevention Program**: MPMW currently implements a program to inspect private backflow prevention devices to ensure that they are working properly. West Yost recommends that adequate resources be provided for this program, as it is an essential program to minimize the potential for cross-connection and pathogen intrusion.

- **Develop Standard Details and Design Guidelines:** MPMW is currently developing standard details and design guidelines. This project should incorporate recommendations for developing seismic design standards.
- Construction of Metered Connections with East Palo Alto: MPMW has many interconnections with East Palo Alto near the Bay Front Area and there have been instances where valves at these interconnections have been wrongly turned. In an effort to track water going to/coming from East Palo Alto, it is recommended that these locations be equipped with meters to capture this information. MPMW should also evaluate whether some of these connections could be consolidated to a few key locations to reduce costs, since the some of these connections are located less than within 0.25 miles from one another.
- **Develop a Lead Service Replacement Program:** California Senate Bill 427 (SB 427) amends the State Health and Safety Code and requires all public water systems to compile an inventory of known partial or total lead user service lines in use in its distribution system by July 1, 2018. The bill also requires that that the public water system take action and replace all known lead user service lines and use service lines constructed of unknown material by July 1, 2020. MPMW is currently working on developing an inventory of its service lines to comply with SB 427. Once the inventory has been developed, it is recommended that a Lead Service Replacement Program be developed shortly after, to replace service lines that are not compliant.
- **Develop an Asset Management Program:** To further MPMW rehabilitation and replacement efforts, it is recommended that an Asset Management Program be developed. An Asset Management Program would collect additional condition data from the various MPMW water facilities and identify infrastructure that is in need of replacement. Capital expenditures would then be prioritized to be spent in rehabilitating or replacing infrastructure that is deficient (i.e., capacity) and/or is in the worst condition.

7.8 SUMMARY OF RECOMMENDED IMPROVEMENTS

Table 7-11 summarizes recommended improvements identified in the capacity, seismic vulnerability, rehabilitation and replacement and advanced metering evaluations, as well as additional improvements identified during the course of the study. For each improvement, the reason for the improvement is provided.

7.9 REFERENCES

ISO, 2017. Water-Supply Evaluations. Accessed November 13, 2017: https://firechief.iso.com/FCWWeb/mitigation/ppc/3000/ppc3010.jsp

Menlo Park Fire District, 2017. Staff report, April 18, 2017, accepting the ISO PPC score of 2. Accessed November 13, 2017: http://sire.menlofire.org/sirepub/agdocs.aspx?doctype=agenda&itemid=17399

Table 7-11. Recommended Existing Water System Improvements

CIP ID	Zone	Improvement Description	Location	Reason for Improvement
Capacity Improvements				
Various	Lower, High Pressure	Recommendations for new pipelines to improve fire flow capacity, and new storage to meet operational, fire flow and emergency needs. See Chapter 8 for project descriptions sizing and locations.		Improvements to address capacity deficiencies
Reliability Improvements				
REL-01	Upper	Upgrade wood roofs on Sand Hill Reservoirs and mitigate geotechnical concerns	Sand Hill Reservoirs	Mitigate seismic and geotechnical hazards. Specific project dependent on findings of Project REL-07
REL-02	Lower, High Pressure, Upper	Implement a non-structural anchorage program as part of the regular maintenance budget.	System-Wide	Mitigate seismic hazard.
REL-03	Lower	New metered interconnection with Cal Water at the Alma Street Crossing. Project assumes an estimated 2,000 LF of 12-inch pipeline, with a portion within a new pedestrian bridge, and meter within a vault.	At the intersection of El Camino Real and Middle Avenue	Improves emergency supply reliability
REL-04	Lower	New metered interconnection with City of Palo Alto at the Pope Chaucer Bridge (San Francisquito Creek). Project assumes an estimated 250 LF of new 12-inch pipeline, all assumed to be within a new bridge, and a meter within a vault	Along Chaucer Street, between Woodland and Palo Alto Avenues.	Improves emergency supply reliability
REL-05	Lower	Implement a residential/commercial pressure regulator program in the lower zone to help keep customer service pressures from exceeding 80 psi, allowing Chilco and Madera pressure regulating station settings to be set equal to the Burgess PRV station[a]	Various	Allows more use of Chilco and Madera PRV stations, with less reliance on Burgess PRV station.
Rehabilitation and Replacement Improvements				
RR-01	Lower, High Pressure, Upper	Continue pipeline replacement program, budgeted at $1.2M/year (current dollars).	System-Wide	Needed to maintain and improve the system. Pipelines identified in the Seismic Vulnerability Assessment are targeted as highest priority. As part of this program, MPMW should also identify opportunities to re-locate pipelines on private property to current rights-of-way
Other System Improvements and Studies				
MISC-01	Lower, High Pressure, Upper	Conduct pipeline hazard assessment (including field survey of geologic conditions along critical pipeline segments, review of boreholes, update liquefaction and landslide models)	System-Wide	Refines information for pipeline replacements to address seismic hazards.
MISC-02	Lower, High Pressure, Upper	Update pipeline analysis prepared in this study based on updated hazard assessment	System-Wide	Refine information for pipeline replacements to address seismic hazards.
MISC-03	Upper	Conduct geotechnical and structural assessment of Sand Hill Reservoirs	Sand Hill Reservoirs	Addresses current codes which are more stringent than codes in place when structures were designed.
MISC-04	--	Conduct detailed evaluation of Maintenance Building.	Burgess Drive	Assess condition and identify retrofit needs to mitigate seismic hazards.
MISC-05	Lower, High Pressure, Upper	Develop post earthquake operational and recovery plan	System-Wide	Provide plan for operational response and recovery following earthquake
MISC-06	Lower, High Pressure, Upper	Develop a plan and acquire equipment for re-fueling generators following an earthquake.	System-Wide	Specific recommendations to be developed in operational and recovery plans.
MISC-07	--	Develop Standard Details and Design Guidelines	System-Wide	MPMW is currently developing standard details and design guidelines. This project should incorporate seismic design procedures or reference ASCE manual of practice for seismic design of water and sewer pipelines.
MISC-08	Lower, High Pressure, Upper	Meter Replacement/Enhancement Program (assumes full system upgrade to AMI)	System-Wide	Replace aging meters, facilitate data collection and monitoring, reduce water loss.
MISC-09	Lower, High Pressure, Upper	Install pressure monitors and connect all turnouts to SCADA System	At Burgess, Chilco, Madera and Hill turnouts	Improve system monitoring
MISC-10	Lower, High Pressure, Upper	Continue implementation of the backflow prevention program	System-Wide	Protects system from cross-contamination.
MISC-12	Lower	Provides MPMW with a means for metering water that may need to be supplied to East Palo Alto in the event of an emergency.	University Avenue, O'Brien Drive and Willow Road	Provides MPMW with a means for metering water that may need to be supplied to East Palo Alto in the event of an emergency.
MISC-13	Lower, High Pressure, Upper	Improves dated distribution system and decreases the chance of lead poisoning.	System-Wide	Improves dated distribution system and decreases the chance of lead poisoning.
MISC-14	Lower, High Pressure, Upper	Provides MPMW with a roadmap for future capital expenditures in an effort uphold customer service by making targeted improvements to assets that are most critical in function or condition.	System-Wide	Provides MPMW with a roadmap for future capital expenditures in an effort uphold customer service by making targeted improvements to assets that are most critical in function or condition.

(a) Assumes 1,800 meter connection retrofits.

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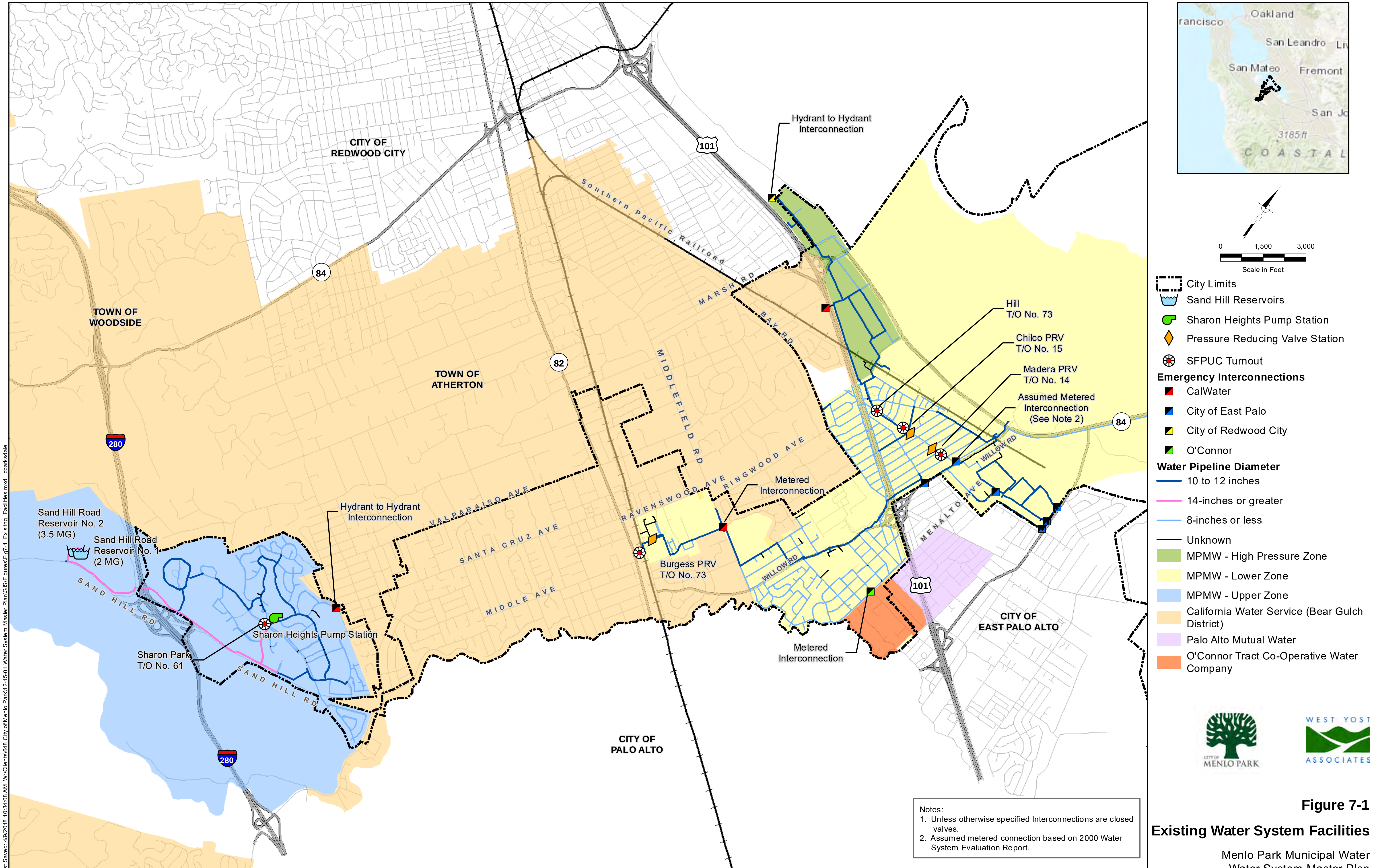

Figure 7-1

Existing Water System Facilities

Menlo Park Municipal Water
Water System Master Plan

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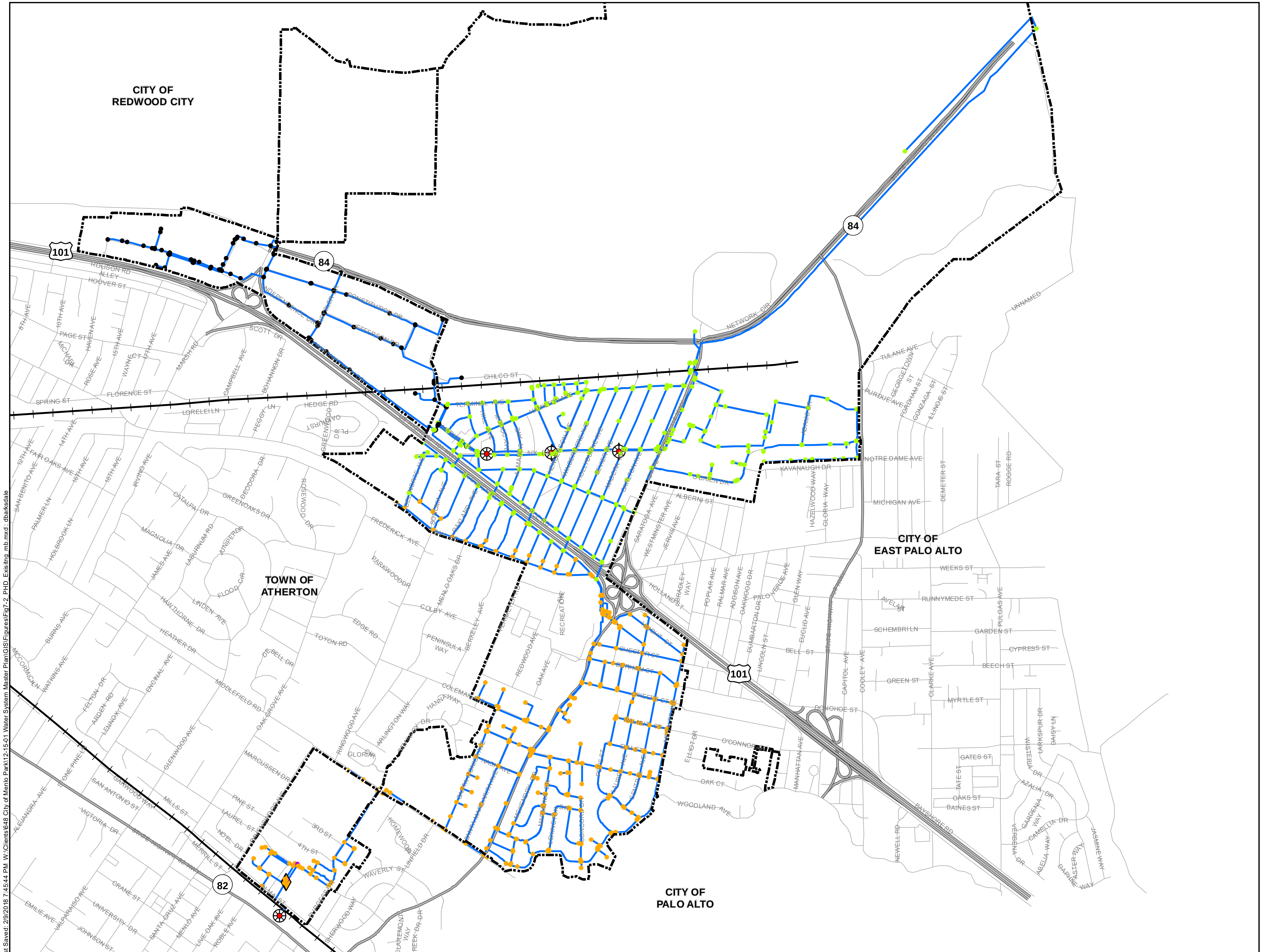

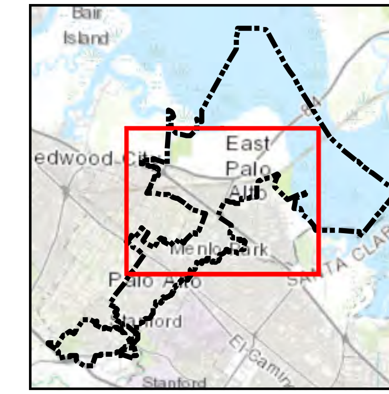

0 900 1,800

Scale in Feet

System Pressure

- 40 psi or less
- 40 psi to 60 psi
- 60 psi to 80 psi
- 80 psi to 100 psi
- 100 psi to 120 psi
- 120 psi or greater
- Sand Hill Reservoirs
- Sharon Heights Pump Station
- Pressure Reducing Valve Station
- SFPUC Turnout
- Existing Pipeline
- Service Area Boundary

Notes:
1. Existing peak hour demand is equal to 10.0 mgd (6,873 gpm).
2. The Sand Hill Reservoirs were assumed to be 75 percent full.

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Figure 7-2A

Existing System Peak Hour Demand Results High Pressure & Lower Zones

Menlo Park Municipal Water
Water System Master Plan

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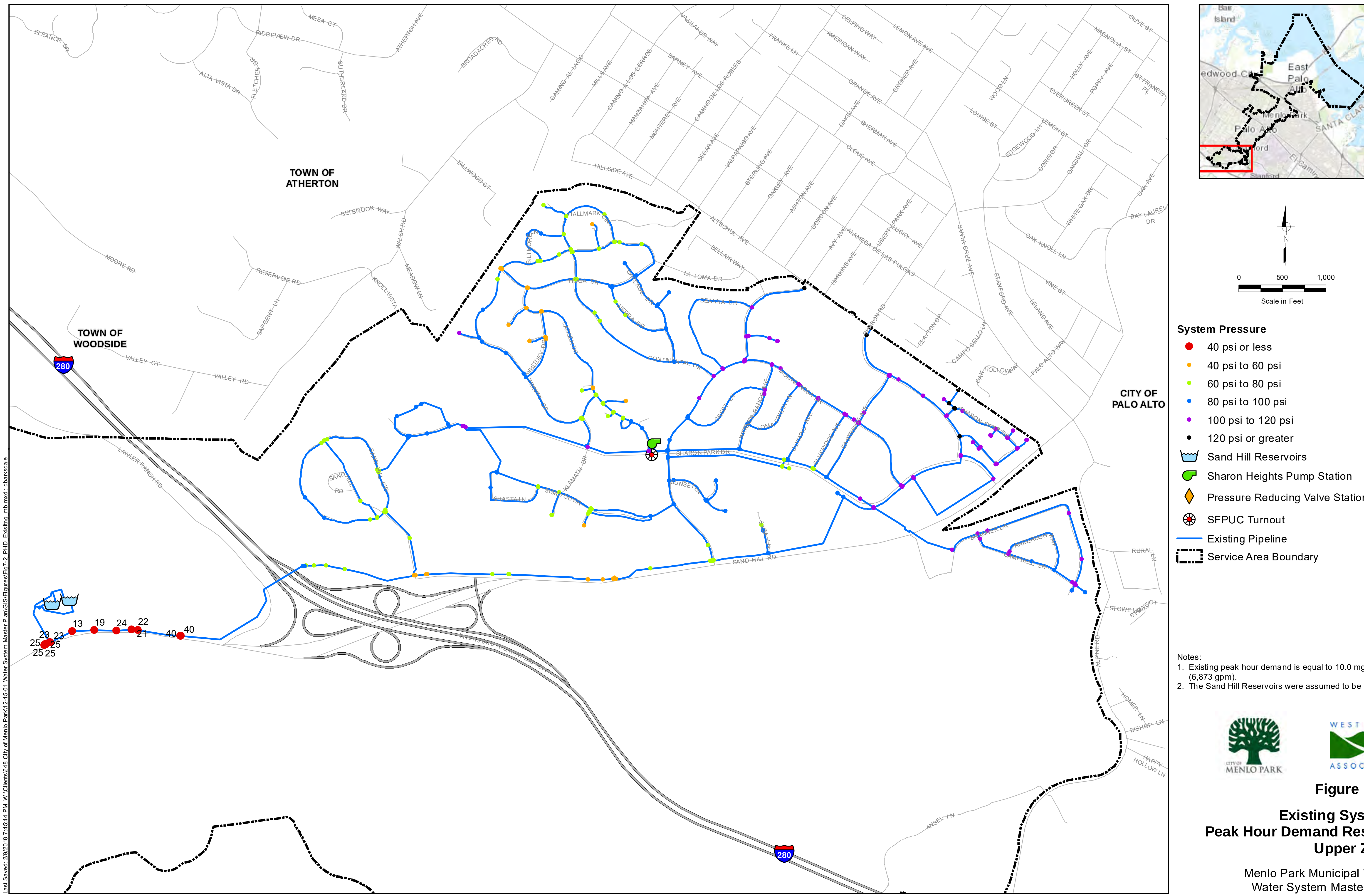

Notes:

1. Existing peak hour demand is equal to 10.0 mgd (6,873 gpm).
2. The Sand Hill Reservoirs were assumed to be 75 percent full.

Figure 7-2B

Existing System Peak Hour Demand Results Upper Zone

Menlo Park Municipal Water
Water System Master Plan

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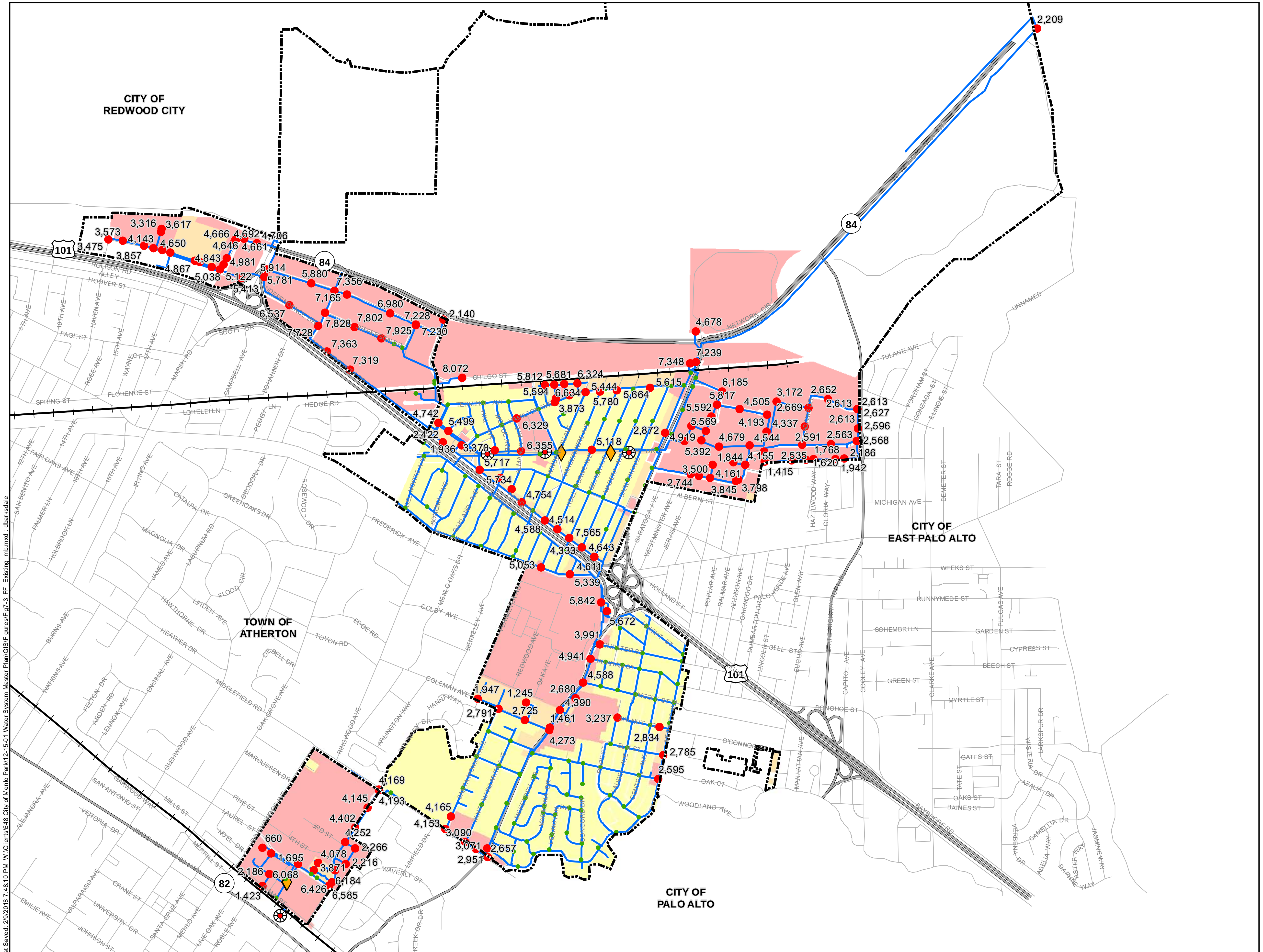

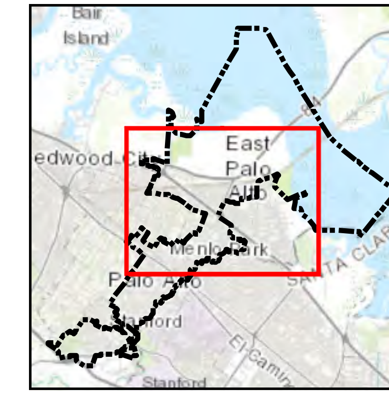

0 900 1,800
Scale in Feet

- Available Flow is less than the Required Fire Flow
- Available Flow meets or exceeds the Required Fire Flow
- Sand Hill Reservoirs
- Sharon Heights Pump Station
- Pressure Reducing Valve Station
- SFPUC Turnout
- Existing Pipeline

Fire Flow Requirement (Non-Sprinklered/Sprinklered)

- Commercial/Industrial/Institutional (8000 gpm/4000 gpm)
- Multi-Family Residential (8000 gpm/4000 gpm)
- Single Family Residential (1000 gpm/500 gpm)

Notes:
1. Results based on maintaining a minimum residual pressure of 20 psi at customer service connections.
2. Labeled value adjacent to nodes is the associated Available Fire Flow, reported in gallons per minute (gpm).

CITY OF MENLO PARK

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Figure 7-3A

Existing System Fire Flow Results under Non-Sprinklered Criteria for High Pressure & Lower Zones

Menlo Park Municipal Water
Water System Master Plan

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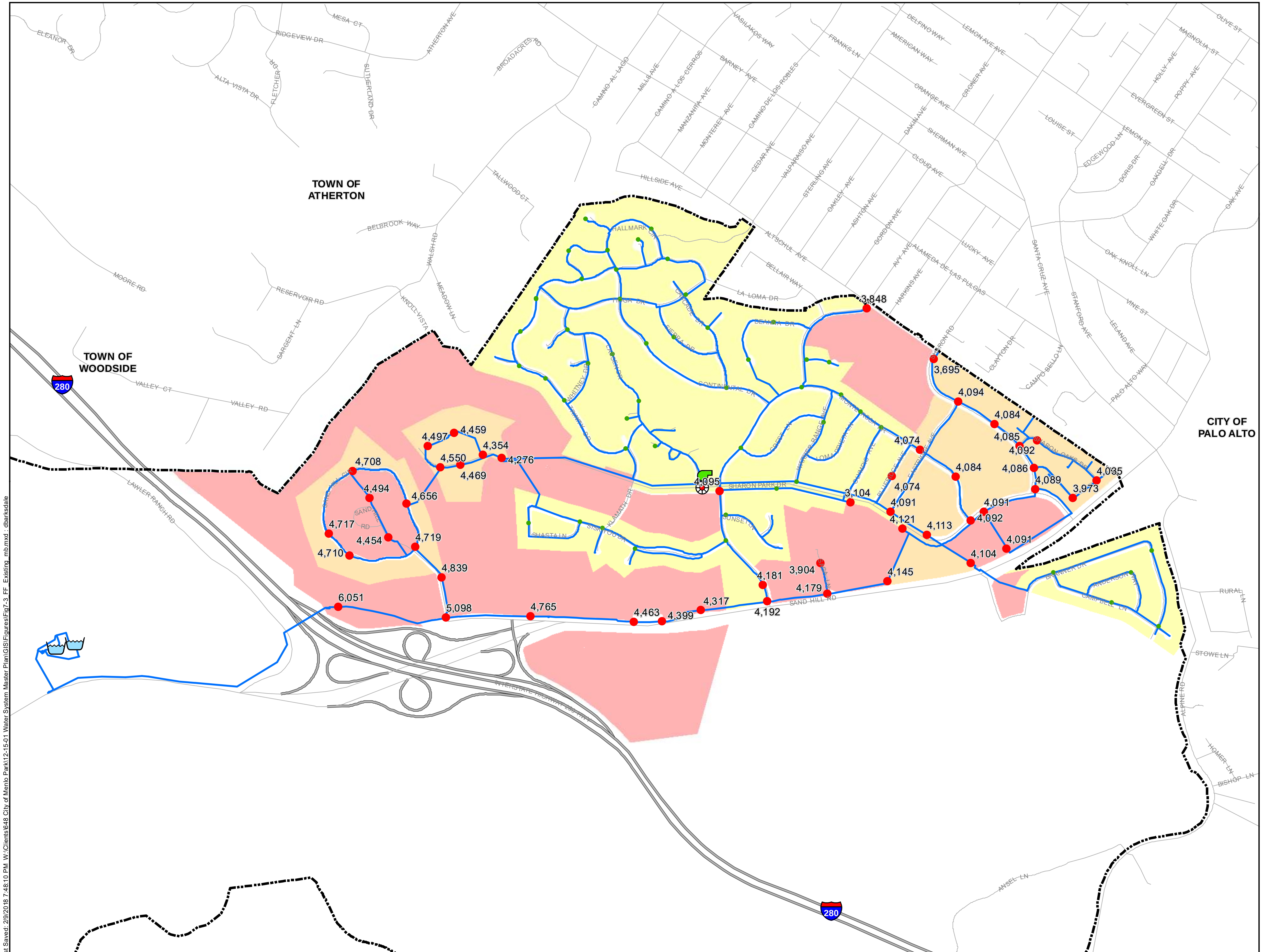

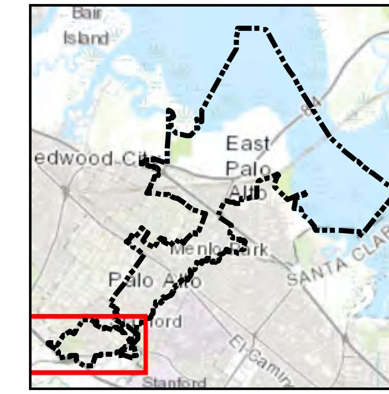

N

0 500 1,000

Scale in Feet

- Available Flow is less than the Required Fire Flow
- Available Flow meets or exceeds the Required Fire Flow
- Sand Hill Reservoirs
- Sharon Heights Pump Station
- Pressure Reducing Valve Station
- SFPUC Turnout
- Existing Pipeline

Fire Flow Requirement (Non-Sprinklered/Sprinklered)

- Commercial/Industrial/Institutional (8000 gpm/4000 gpm)
- Multi-Family Residential (8000 gpm/4000 gpm)
- Single Family Residential (1000 gpm/500 gpm)

Notes:
1. Results based on maintaining a minimum residual pressure of 20 psi at customer service connections.
2. Labeled value adjacent to nodes is the associated Available Fire Flow, reported in gallons per minute (gpm).

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Figure 7-3B

Existing System Fire Flow Results under Non-Sprinklered Criteria for Upper Zone

Menlo Park Municipal Water
Water System Master Plan

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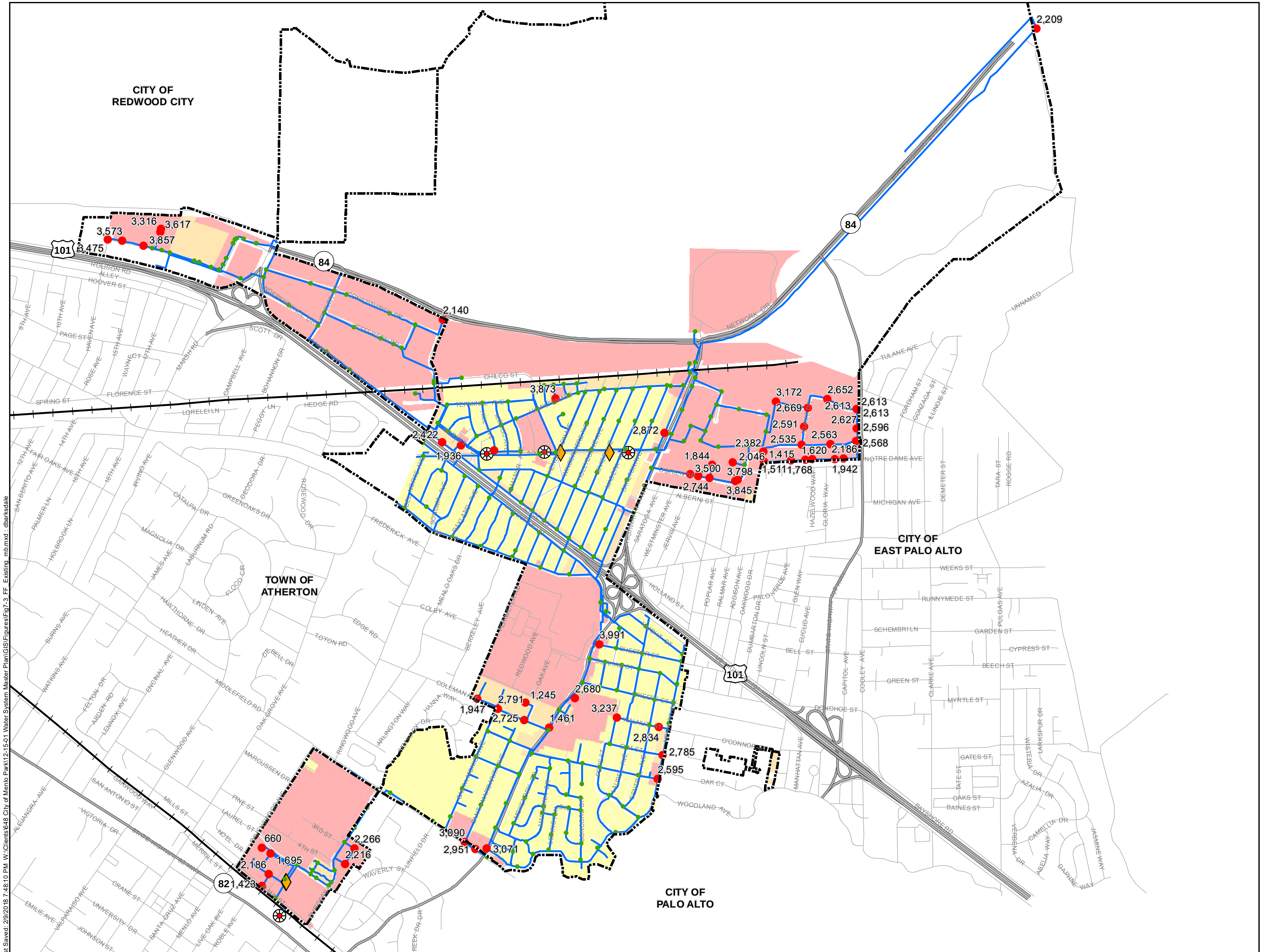

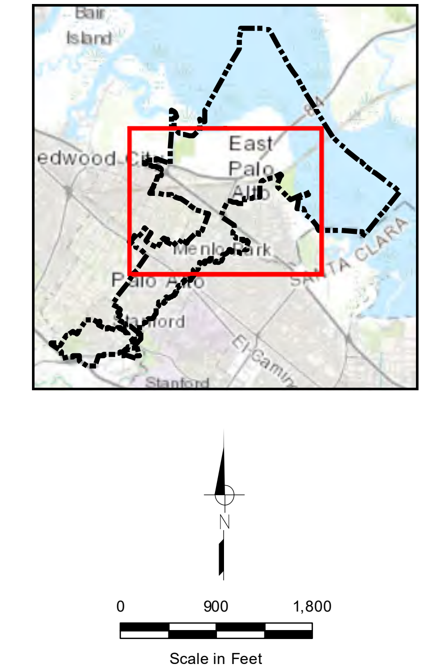

- Available Flow is less than the Required Fire Flow
- Available Flow meets or exceeds the Required Fire Flow
- Sand Hill Reservoirs
- Sharon Heights Pump Station
- Pressure Reducing Valve Station
- SFPUC Turnout
- Existing Pipeline

Fire Flow Requirement (Non-Sprinklered/Sprinklered)

- Commercial/Industrial/Institutional (8000 gpm/4000 gpm)
- Multi-Family Residential (8000 gpm/4000 gpm)
- Single Family Residential (1000 gpm/500 gpm)

Notes:
1. Results based on maintaining a minimum residual pressure of 20 psi at customer service connections.
2. Labeled value adjacent to nodes is the associated Available Fire Flow, reported in gallons per minute (gpm).

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Figure 7-3C

Existing System Fire Flow Results under Sprinklered Criteria for High Pressure & Lower Zones

Menlo Park Municipal Water
Water System Master Plan

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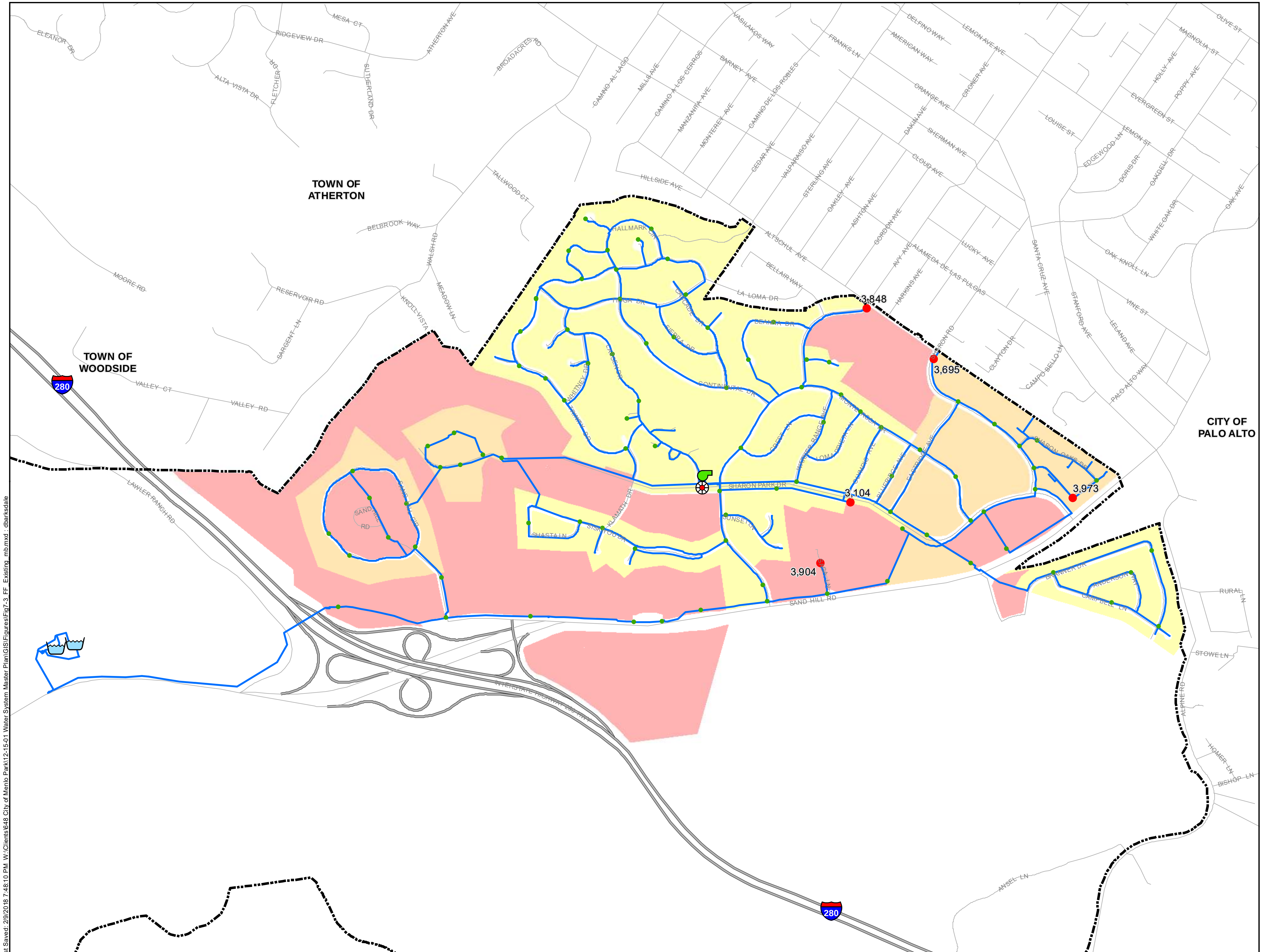

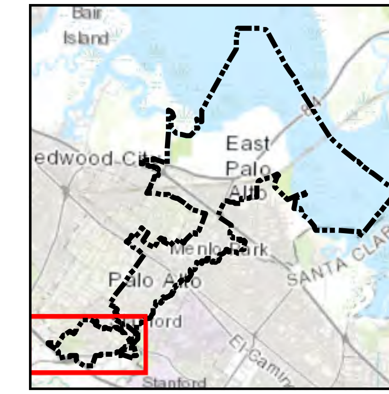

N

0 500 1,000
Scale in Feet

- Available Flow is less than the Required Fire Flow
- Available Flow meets or exceeds the Required Fire Flow
- Sand Hill Reservoirs
- Sharon Heights Pump Station
- Pressure Reducing Valve Station
- SFPUC Turnout
- Existing Pipeline

Fire Flow Requirement (Non-Sprinklered/Sprinklered)

- Commercial/Industrial/Institutional (8000 gpm/4000 gpm)
- Multi-Family Residential (8000 gpm/4000 gpm)
- Single Family Residential (1000 gpm/500 gpm)

Notes:
1. Results based on maintaining a minimum residual pressure of 20 psi at customer service connections.
2. Labeled value adjacent to nodes is the associated Available Fire Flow, reported in gallons per minute (gpm).

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Figure 7-3D

Existing System Fire Flow Results under Sprinklered Criteria for Upper Zone

Menlo Park Municipal Water
Water System Master Plan

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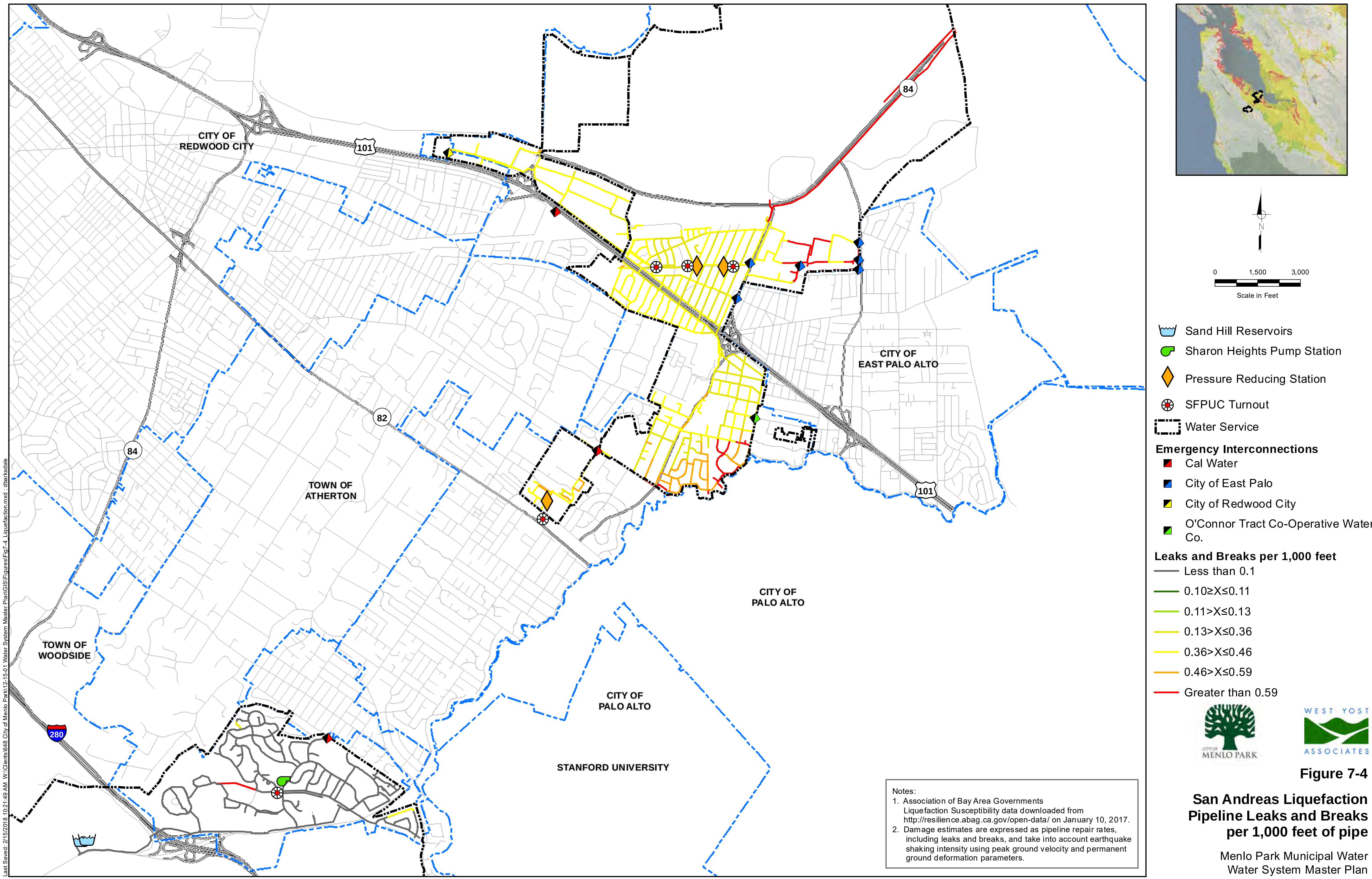

Figure 7-4

San Andreas Liquefaction Pipeline Leaks and Breaks per 1,000 feet of pipe

Menlo Park Municipal Water
Water System Master Plan

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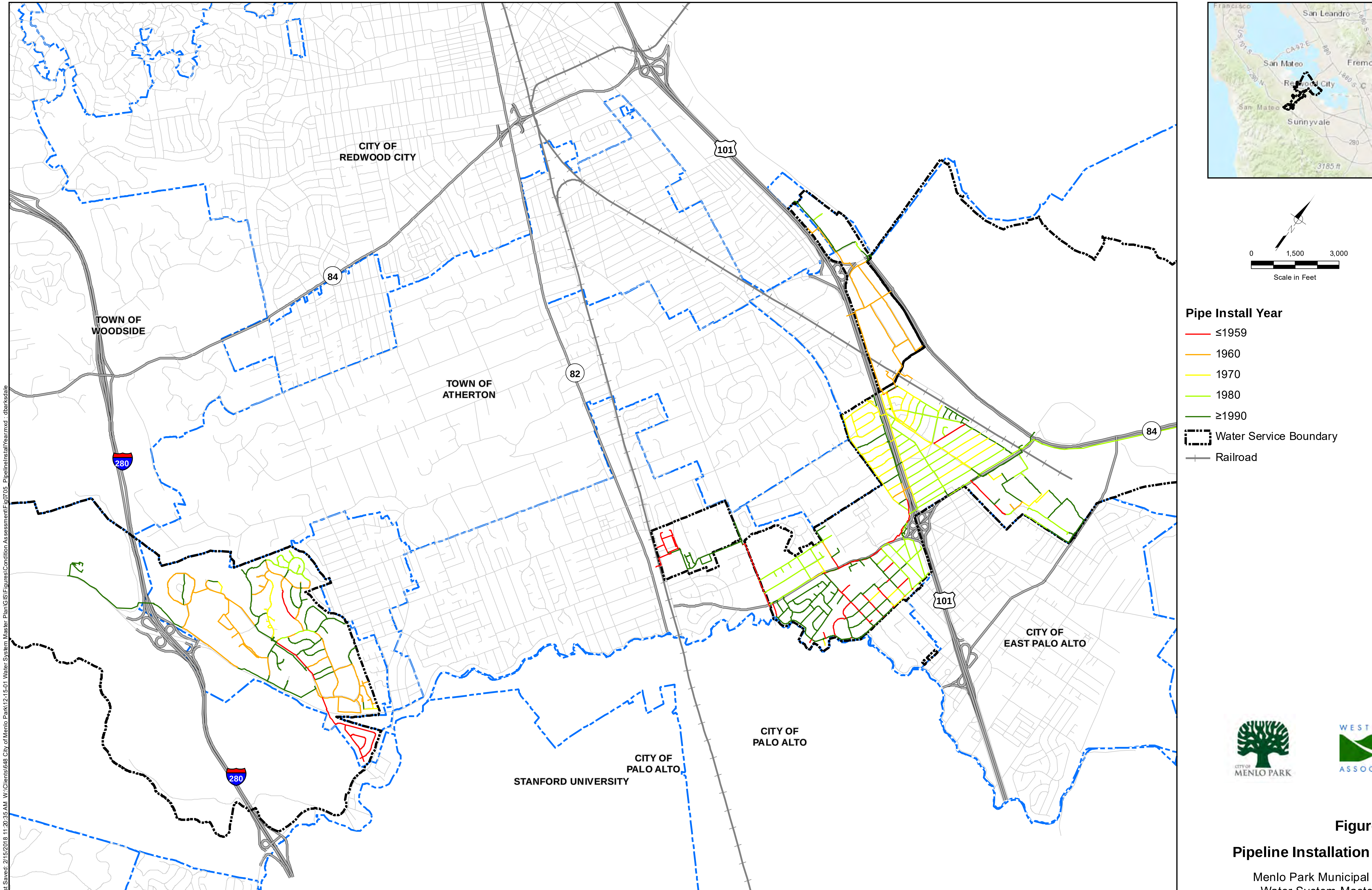

Figure 7-5

Pipeline Installation Year

Menlo Park Municipal Water
Water System Master Plan

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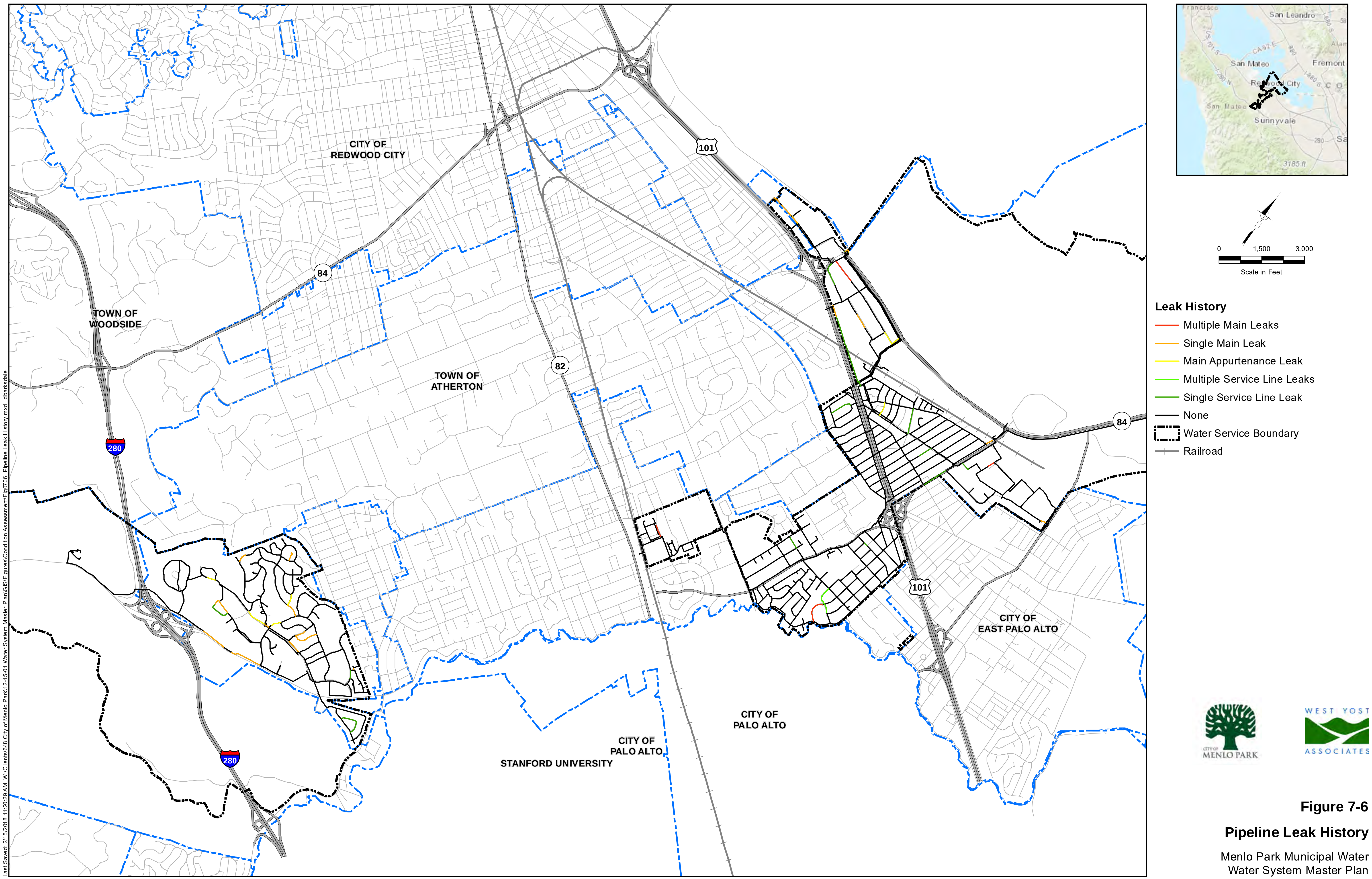

Figure 7-6

Pipeline Leak History

Menlo Park Municipal Water
Water System Master Plan

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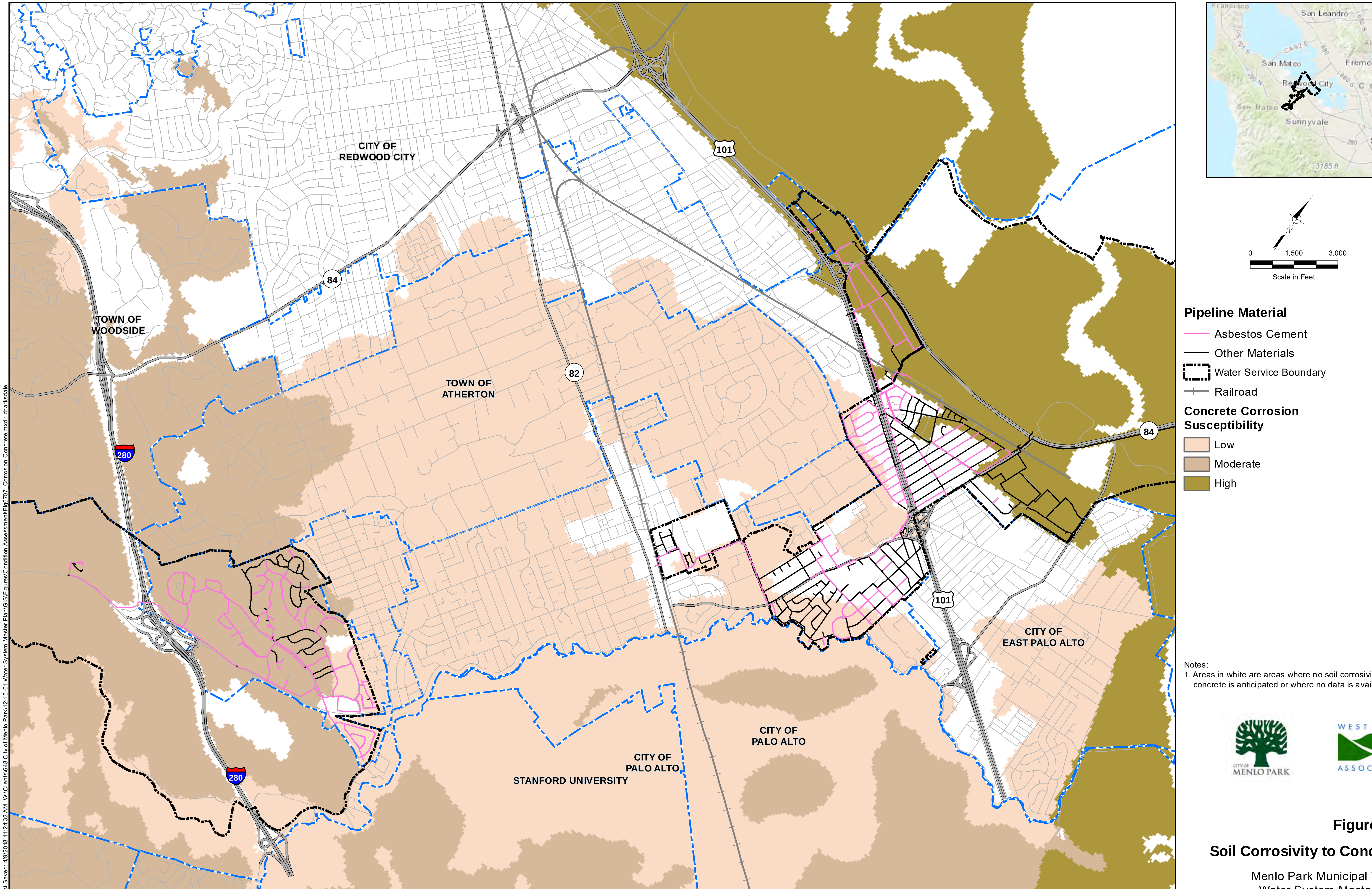

Notes:
1. Areas in white are areas where no soil corrosivity to concrete is anticipated or where no data is available.

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Figure 7-7

Soil Corrosivity to Concrete

Menlo Park Municipal Water
Water System Master Plan

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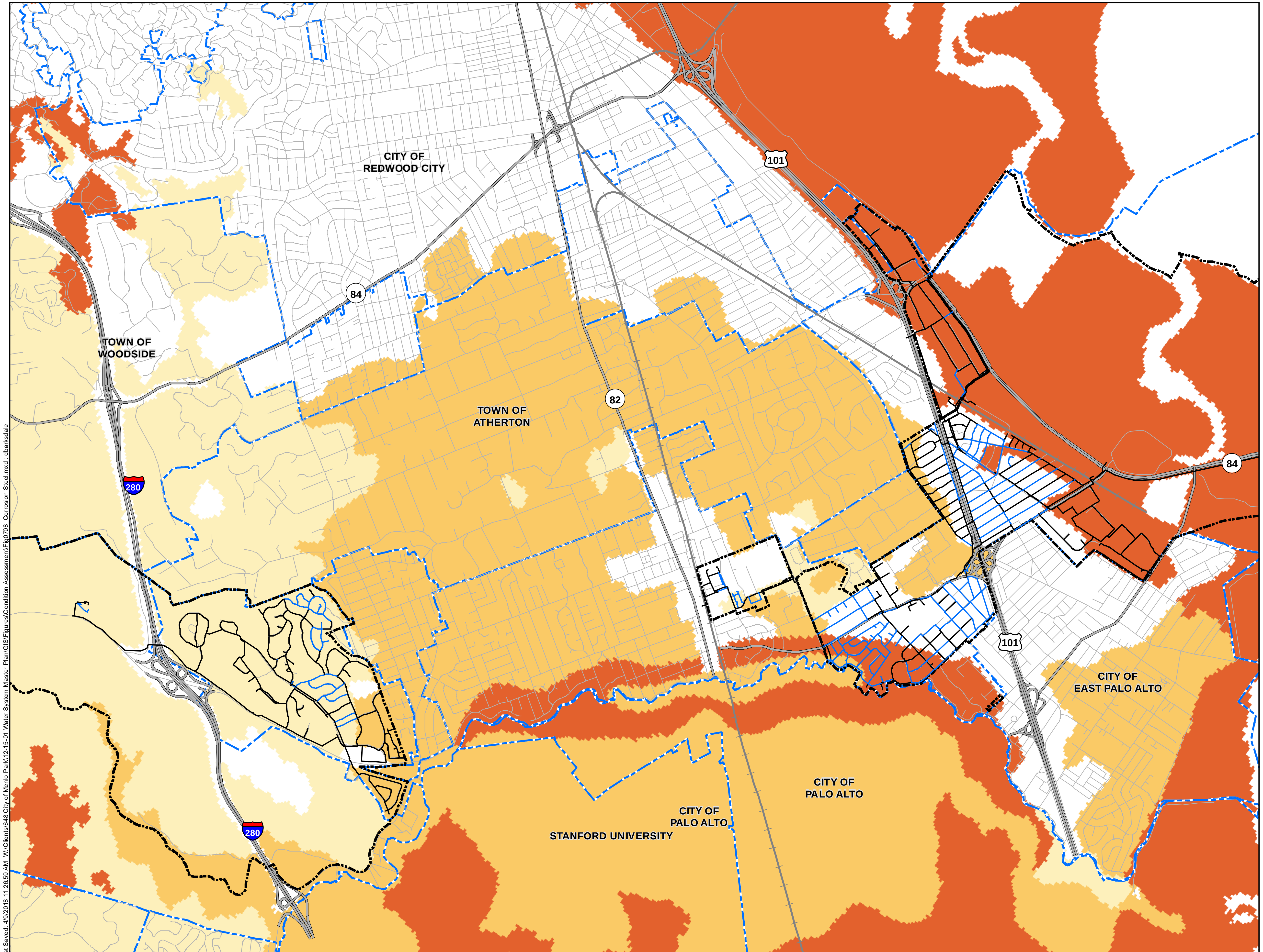

0 1,500 3,000
Scale in Feet

Pipeline Material

- Metal Pipeline
- Other Pipeline Materials
- Water Service Boundary
- Railroad

Steel Corrosion Susceptibility

- Low
- Moderate
- High

Notes:
1. Areas in white are areas where no soil corrosivity to steel is anticipated or where no data is available.

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Figure 7-8

Soil Corrosivity to Steel

Menlo Park Municipal Water
Water System Master Plan

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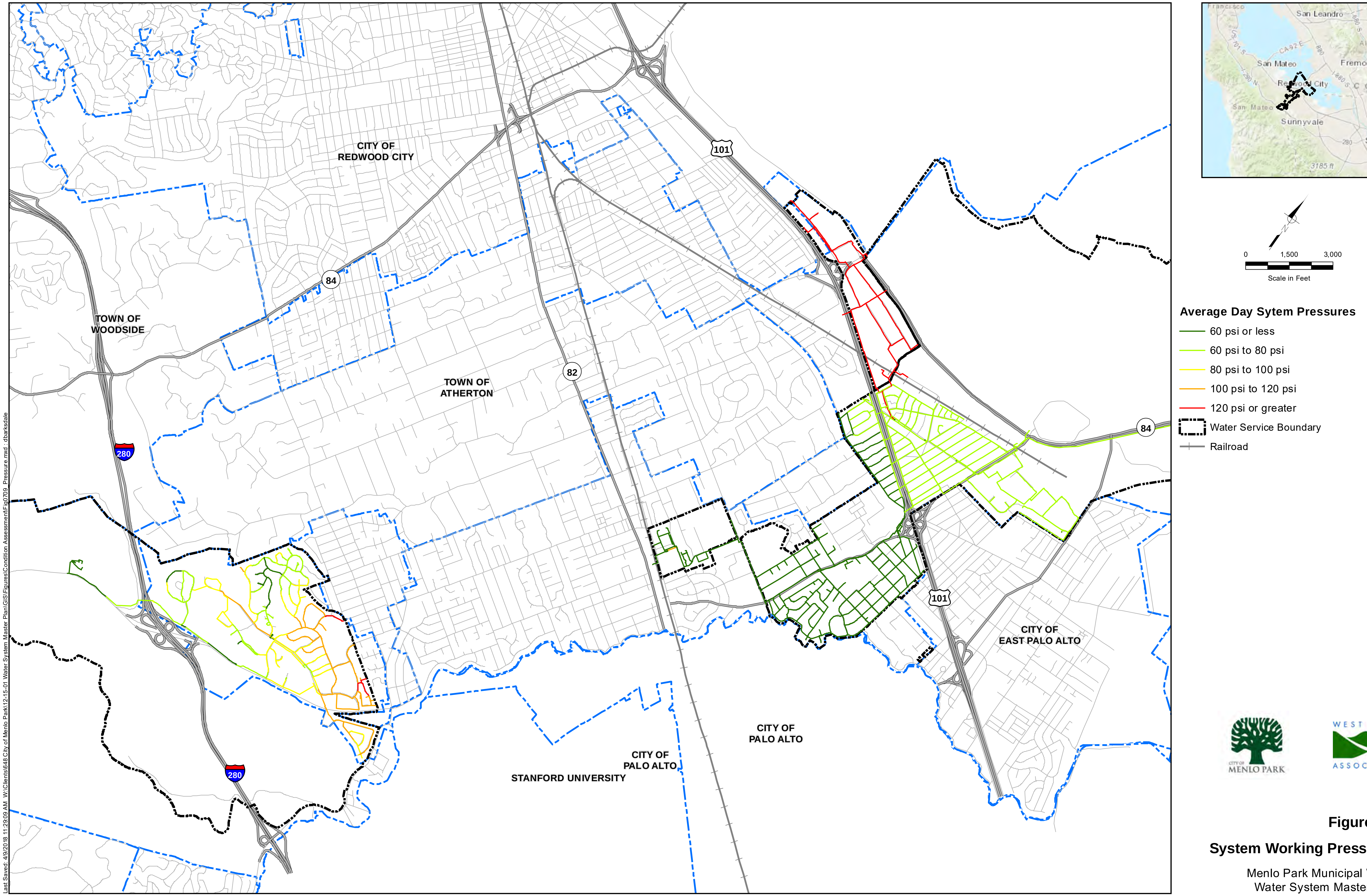

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Figure 7-9

System Working Pressures

Menlo Park Municipal Water
Water System Master Plan

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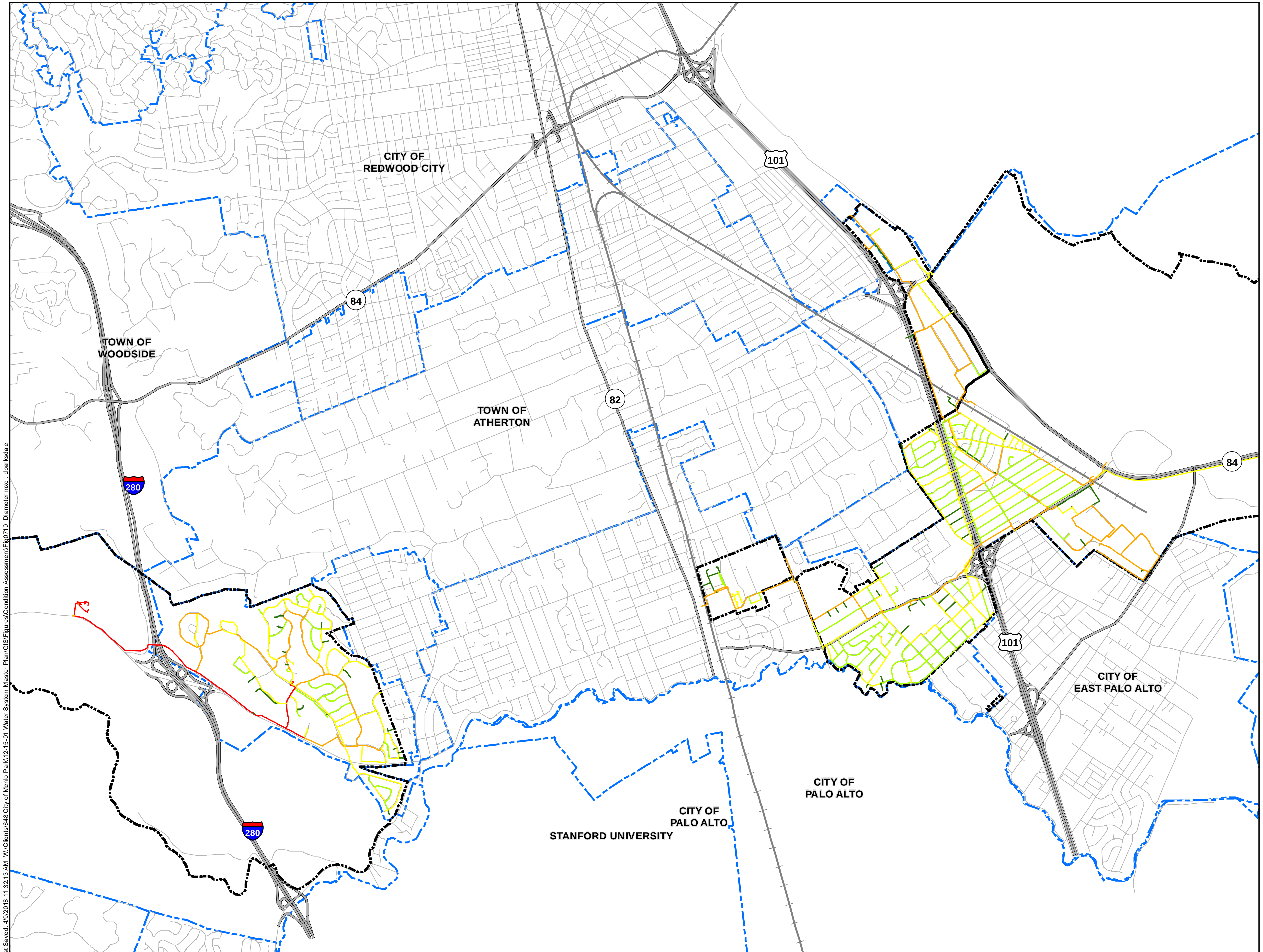

0 1,500 3,000
Scale in Feet

Diameter

- <6"
- 6"
- 8"
- 10 - 12"
- >14"
- Water Service Boundary
- Railroad

Figure 7-10

Pipeline Diameter

Menlo Park Municipal Water
Water System Master Plan

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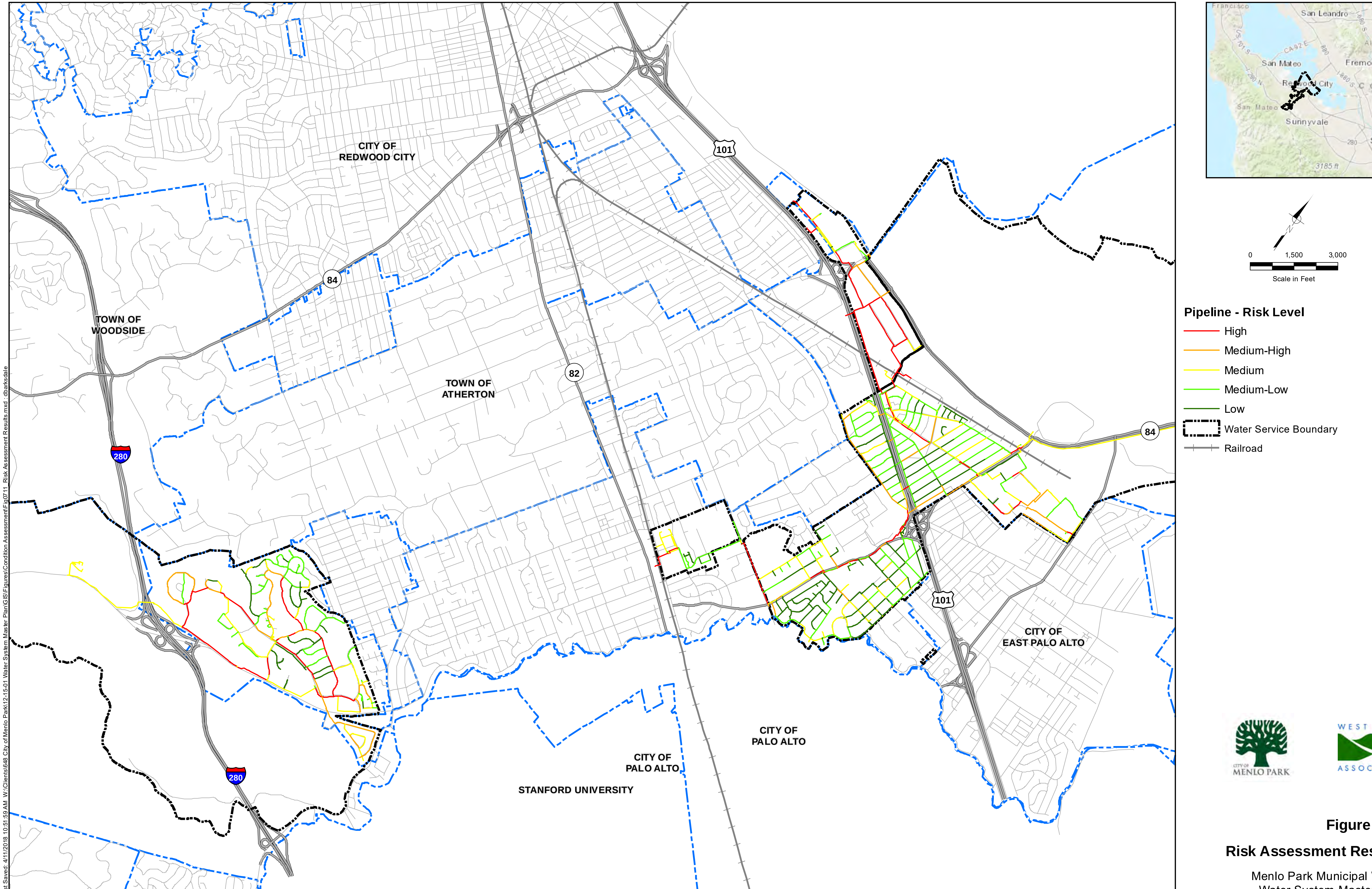

Figure 7-11

Risk Assessment Results

Menlo Park Municipal Water
Water System Master Plan

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CHAPTER 8
Future Water System Evaluation

This chapter presents the evaluation of the MPMW future water distribution system and its ability to meet MPMW's recommended planning and design criteria under future water demand conditions. West Yost conducted this evaluation using the future demand conditions summarized in Chapter 3.

The future water system evaluation includes both system capacity and performance evaluations. The system capacity evaluation includes an analysis of supply and water storage capacity. The system performance evaluation assesses the future water system's ability to meet recommended planning and design criteria under normal (peak hour demand conditions) or fire flow conditions (future maximum day or peak hour demand plus fire flow). West Yost also evaluated the future water system water quality and the system's ability to perform under emergency outage conditions (assuming loss of SFPUC supply in the Lower and High Pressure zones). West Yost conducted the future system performance evaluations using the hydraulic model developed for this WSMP, which is described in Chapter 6, and used to conduct the existing system evaluation, described in Chapter 7.

Evaluations, findings, and recommendations for addressing any deficiencies identified in the future water distribution system are included in this chapter. Recommendations were used to develop a capital improvement program, which is described in Chapter 9.

The following sections present the evaluation methodology and results from the future water system evaluation:

- Projected Water Demands by Pressure Zone
- Future System Configuration
- Future Water System Facility Capacity Evaluation
- Future Water System Performance Evaluation
- Summary of Recommended Improvements for the Future Water System

8.1 PROJECTED WATER DEMANDS BY PRESSURE ZONE

Table 8-1 summarizes the water demands used for the future water system evaluation by pressure zone. As discussed in Chapter 3, growth projections and corresponding future water demands were developed from water analysis zone (WAZ) areas, which defined growth and associated future water demands within the MPMW service area. The future water demands were spatially located into the hydraulic model using the WAZ areas. Demands within each WAZ were spread equally to the demand nodes in the WAZ area.

Table 8-1. Water Demands, Future Conditions						
Pressure Zone	Average Day Demand[a]		Maximum Day Demand[b]		Peak Hour Demand[c]	
	gpm	mgd	gpm	mgd	gpm	mgd
Lower Zone	1,538	2.2	2,370	3.4	3,334	4.8
High Pressure Zone	632	0.9	973	1.4	1,369	2.0
Upper Zone	901	1.3	1,712	2.5	3,424	4.9
Total	**3,071**	**4.4**	**5,055**	**7.3**	**8,126**	**11.7**

(a) Future average day demand based on Water Analysis Zone projections for 2040, provided by MPMW.

(b) Maximum day demand is equal to the associated pressure zone peaking factor multiplied by the average day demand, refer to Table 3-7.

(c) Peak Hour demand is equal to the associated pressure zone peaking factor multiplied by the average day demand, refer to Table 3-7.

As indicated in Table 8-1, MPMW's future average day demand is expected to be 4.4 mgd, an increase of approximately 22 percent over existing average day demand. The Lower and Upper pressure zones are expected to experience a minor growth in demand. However, the High Pressure Zone demand is expected to more than triple its existing use. From a planning and forecasting perspective, this future demand is estimated to occur around 2040.

8.2 FUTURE SYSTEM CONFIGURATION

The future system evaluations described in this chapter used a configuration that is the same as the current system configuration. Initially, integration of the High Pressure Zone and the Lower Zone was considered, since land uses within the High Pressure Zone are changing from industrial use to commercial and multi-family residential use, which do not require high operating pressures under normal operating conditions. This was considered in an effort to minimize the amount of storage needed. However, upon review with the Menlo Park Fire District, many of the new developments have fire flow sprinkler systems that are designed for the current high-pressure conditions, and would be negatively impacted if the High Pressure Zone were to be regulated to a lower pressure in the future. Therefore, integration of the High Pressure Zone and Lower Zone was only considered during emergencies, such as an outage of the turnout supplying the High Pressure Zone. This would be achieved by the installation of check valves where valves are currently closed to isolate the zones, so that if there were a pressure loss in the High Pressure Zone, the check valves would open to provide flow from the Lower Zone to the High Pressure Zone.

The future system is also assumed to include two to three wells in the Lower Zone, to provide a total supply capacity of 3,000 gpm in an emergency. As part of the Supplemental Emergency Supply Program, one 1,500 gpm well has been installed and will be completed by the end of 2017. One or more additional wells are planned, to provide a total supply capacity of 3,000 gpm during emergencies.

CalTrans is replacing the existing interchange and bridge with a partial cloverleaf-style interchange at the Willow Road and Highway 101 Interchange. As part of this project, CalTrans is also upgrading utilities, including water pipelines. This project was not included in the future system model, as it is not expected to have a significant impact on system hydraulics and will be integrated into the hydraulic model once the project is completed, and as-built drawings are available. Caltrans expects to complete work on the interchange in 2018.

8.3 FUTURE WATER SYSTEM FACILITY CAPACITY EVALUATION

To evaluate the capacity of the future water system facilities, the following analyses were conducted:

- Supply Capacity Evaluation
- Storage Capacity Evaluation

The results of the future water system facility capacity evaluations are discussed below.

8.3.1 Supply Capacity Evaluation

The supply capacity of MPMW's future water system was evaluated to assess the system's ability to deliver a reliable firm capacity to serve the existing water service area. Firm capacity assumes a reduction in total supply or pumping capacity to account for facilities that are out of service at any given time due to mechanical breakdowns, maintenance, water quality, or other operational issues. For booster pump stations, firm booster pumping capacity was defined as the total booster pump station capacity with the largest pump out of service. For pressure regulating stations, which are hydraulically actuated and are less prone to mechanical failure, the firm capacity was assumed to equal the total station capacity with all valves in service.

The firm supply or pumping capacity within each pressure zone must equal or exceed: (1) the maximum day demand in zones with storage; or (2) peak hour plus fire flow in zones without storage. In zones with storage, maximum day plus fire flow and peak hour demands are met from a combination of zone supply and storage.

Table 8-2 compares the existing firm supply capacity with required firm supply for future water demand conditions. The left-hand side of the table shows the pressure zones, and their associated supplies serving the zone. The right-hand side of the table shows the existing supply capacity, the required firm supply capacity based on the supply capacity criterion, and the difference between the existing firm supply capacity and the required firm supply capacity.

Table 8-2. Comparison of Available and Required Supply Capacity, Future Conditions

Pressure Zone	Supply Sources		Supply Capacity[a]	Future Firm Supply Capacity, gpm[b]	Required Firm Supply Capacity[b], gpm		Firm Supply Capacity Surplus (Deficit), gpm
Lower Zone	Chilco Pressure Regulating Station	8-inch PRV	3,100	11,700	Peak Hour + FF	11,334	366
		4-inch PRV	800				
	Madera Regulating Station	8-inch PRV	3,100				
		4-inch PRV	800				
	Burgess Regulating Station	8-inch PRV	3,100				
		4-inch PRV	800				
High Pressure Zone	SFPUC Turnout 13	Open Connection[c]	4,230	4,230	Peak Hour + FF	9,369	(5,139)
Upper Zone	Sharon Heights PS[d]	Pump 1	1,550	2,800	Maximum Day Demand	1,712	1,088
		Pump 2	1,550				
		Pump 3	1,550				

(a) Valve capacities based on intermittent maximum flow capacity for ClaVal model 90-01 (100-01 Hytrol internal port). However actual flow capacity will vary based on system conditions.

(b) Zones with storage have a required firm supply capacity equal to the maximum day demand. Zones without storage have a required firm supply capacity equal to the peak hour demand plus fire flow. Fire flow based on largest fire flow requirement (see Table 5-2) in the pressure zone and assumed to be unsprinklered for planning purposes.

(c) High Pressure Zone supplied directly from SFPUC via Turnout 13 and is not regulated. Supply capacity was limited to 4,230 gpm based on a recommended maximum velocity of 12 feet/sec, during fire flow conditions. However, the hydraulic evaluation indicates that fire flows can still be met at sufficient residual pressures at most locations, therefore no improvements are recommended.

(d) Firm capacity at Sharon Heights PS is defined as the total capacity of all pumps, minus the capacity of the largest pumping unit. However, based on MPMW the actual firm capacity, based on performance testing, is equal to 2,800 gpm.

Table 8-2 indicates that the Lower Zone and Upper Zone have surplus supply capacities of approximately 370 and 1,090 gpm respectively. Based on the criterion listed in Chapter 5, the High Pressure Zone supply capacity is limited to 4,230 gpm, which is calculated as the maximum flow rate with a 12 feet per second flow velocity constraint through a 12-inch diameter pipeline. The High Pressure Zone has a supply capacity deficit of approximately 5,140 gpm, when comparing supply capacity with unsprinklered fire flow requirements, when limiting flow based on the above-described maximum velocity criterion. The deficit would drop to 1,139 gpm with sprinklered fire flow requirements, which are 50 percent of unsprinklered fire flow requirements, since it is anticipated that as development continues, the majority of buildings will be sprinklered. This supply capacity deficit would only need to be addressed if the hydraulic evaluation shows that sufficient flow cannot be provided to the pressure zone to meet fire flow conditions. The hydraulic analysis discussed in Section 8.4.2 did not show a deficiency and fire flows within the High Pressure Zone can be supplied with sufficient residual pressure at most locations. Locations that did not meet fire flow requirements are confined to areas where there are single feeds to areas that have small diameter pipelines serving them. Improvements to these areas are recommended and are discussed in more detail in subsequent sections.

8.3.2 Storage Capacity Evaluation

The principal advantages that storage provides for the water system are: operational storage to balance differences in demands and supplies; emergency storage in case of supply failure; and water to fight fires. MPMW's water storage capacity requirement is to provide an operational storage component equal to 25 percent of a maximum day demand, an emergency storage component equal to 50 percent of a maximum day demand and a fire flow storage component equal to the highest fire flow and duration recommended in a particular pressure zone based on land uses within the pressure zone.

Table 8-3 compares MPMW's available water storage capacity with the required storage capacity by pressure zone, under multiple available storage configurations. Existing storage capacities reported in the table are based on nominal storage capacities calculated from tank geometry.

The storage table includes results for three scenarios with differing assumptions for the Lower Zone and High Pressure Zone. The first scenario evaluates the future system with the planned emergency well supply being implemented for the Emergency Water Supply Program. An emergency storage credit is applied to account for the well supply, where the emergency storage credit is calculated as the minimum of: 1) the emergency storage requirement (volume equal to 0.5 times maximum day demand, or 1.71 MG); or, 2) the volume produced by the wells, assuming an emergency with a 24-hour duration occurring on the maximum demand day (4.32 MG). The second scenario evaluates the future system with two emergency wells and the fire flow requirement reduced by 50 percent, since all new developments in the zone will be sprinklered. The third scenario evaluates the future system with the two emergency wells, reduced fire flow requirements, and integration of the Lower Zone and High Pressure Zone by adding check-valve connections that would open to interconnect the High Zone and Lower Zone during an emergency. Scenarios 2 and 3 are the same for the Upper Zone.

Table 8-3. Comparison of Available and Required Storage Capacity, Future Conditions

[A]	[B]	[C]	[D]	[E]	[F] = [D]+[E]	[G]	[H]	[I]	[J] = [G] + [H] + [I]	[K] = [F] - [J]
		Available Storage Capacity, MG				Required Storage Capacity, MG				
Pressure Zone	Maximum Day Demand, mgd	Facility	Storage Capacity	Emergency Groundwater Storage Credit	Total Available Storage Capacity	Operational[(a)]	Emergency[(b)]	Fire Flow[(c)]	Total Required Storage Capacity	Storage Capacity Surplus (Deficit), MG
Future System with 2 Emergency Wells (each @ 1,500 gpm)										
Lower Zone	3.4	*Emergency Groundwater Wells* [(d)]	0.00	1.71	1.71	0.85	1.71	1.92	4.48	(2.77)
High Pressure Zon	1.4	--	0.00	0.00	0.00	0.35	0.70	1.92	2.97	(2.97)
Upper Zone	2.5	Sand Hill Reservoirs	5.50	0.00	5.50	0.62	1.23	1.92	3.77	1.73
Future System with 2 Emergency Wells (each @ 1,500 gpm) and Reduced Fire Flow Requirements [(f)]										
Lower Zone	3.4	*Emergency Groundwater Wells* [(d)]	0.00	1.71	1.71	0.85	1.71	0.96	3.52	(1.81)
High Pressure Zon	1.4	--	0.00	0.00	0.00	0.35	0.70	0.96	2.01	(2.01)
Upper Zone	2.5	Sand Hill Reservoirs	5.50	0.00	5.50	0.62	1.23	0.96	2.81	2.69
Future System with 2 Emergency Wells (each @ 1,500 gpm), Check Valve Connections between High Pressure and Lower Zones, and Reduced Fire Flow Requirements [(f)]										
Lower Zone	3.4	*Emergency Groundwater Wells* [(d)]	0.00	1.71	1.71	0.85	1.71	0.96	3.52	(1.81)
High Pressure Zon	1.4	*Remaining Emergency Groundwater Well Capacity from Lower Zone*	0.00	0.70	0.70	0.35	0.70	0.96	2.01	(1.31)
Upper Zone	2.5	Sand Hill Reservoirs	5.50	0.00	5.50	0.62	1.23	0.96	2.81	2.69

(a) Operational storage is 25 percent of the maximum day demand (See Chapter 5, Table 5-1).
(b) Emergency storage is 50 percent of the maximum day demand (See Chapter 5, Table 5-1).
(c) Fire flow in zones with commercial, industrial, or institutional/governmental customers is 8,000 gpm for 4 hours. Assumed to be unsprinklered for planning purposes (See Chapter 5, Table 5-2).
(d) Groundwater Storage Credit is based on the total volume produced from the planned Emergency Groundwater Well for one day (See Chapter 5, Section 5.4.2.4). A production capacity of 1,500 gpm is used as confirmed by tests on the City's recently completed emergency well.
(e) Groundwater pumping capacity from two wells (assuming 1,500 gpm each) exceeds the emergency storage requirement (50% of a Max Day Demand), therefore the available emergency storage credit was limited to the emergency storage requirement.
(f) The reduction in fire flow requirements assumes buildings in the Lower and High Pressure zones will be updated with sprinklers at buildout, reducing the fire flow requirement to 4,000 gpm for 4 hours.

The comparison between available and required storage capacities indicates that there is a future water storage capacity deficit in the Lower and High Pressure Zones. Depending on the scenario, the storage deficits range from 1.8 MG to 2.8 MG for the Lower Zone, and 1.3 MG to 3.0 MG for the High Pressure Zone. Installing wells in the Lower Zone increases the emergency storage credit and installing check valves between the Lower Zone and High Pressure Zone increases the available storage capacity in the High Pressure Zone. The required storage capacity can also be reduced if sprinklers are installed. The Upper Zone is projected to have a surplus of 1.7 MG to 2.7 MG, based on the fire flow requirements.

MPMW has indicated, based on previous evaluations, that there are no feasible storage sites for the High Pressure Zone. Therefore, a new storage reservoir is recommended for Lower Zone, with a total storage capacity of 2.5 MG, and installation of check valves to interconnect the Lower Zone and High Zone during an emergency. This volume of storage provides for operational, fire and emergency storage for the Lower Zone and emergency storage volume for the High Zone. Operational and fire flow for the High Zone would continue to be provided from SFPUC. Appendix E summarizes minimum site requirements for tanks of various heights. A focused siting study would be needed to determine the location for the new storage tank.

8.4 FUTURE WATER SYSTEM PERFORMANCE EVALUATION

This section discusses the hydraulic performance evaluation of the future water distribution system. The following evaluations were performed to assess distribution system performance under future water demand conditions:

- Normal Operating Conditions: This scenario evaluates customer service pressures in the system during a peak hour demand condition, the highest demand anticipated during normal operations.
- Fire Flow Conditions: This scenario evaluates future fire flow availability in the system under a maximum day demand condition in the Upper Zone, where storage is assumed to supplement supply if a fire were to occur under higher demand conditions, and under a peak hour demand condition in the Lower and High Pressure Zones, where system demand and fire flow must both be met from the supply source, unless storage is constructed in the future.
- Water Quality Operations: Average Day Demand Scenario: This scenario evaluates water age in the system under an average day demand condition, which would be typical of spring or fall operations.
- Emergency Operations: This scenario evaluates customer service pressures in the system during an average day demand condition when all flow is supplied from the two proposed emergency wells.

These four scenarios use the hydraulic model developed for the WSMP to evaluate the future water system performance. The future water system is expected to deliver peak hour flows, maximum day plus fire flow or peak hour demand plus fire flow, and average day demand flow during an emergency within the acceptable pressure, velocity, and head loss ranges as identified in the planning and design criteria presented in Chapter 5. For the Lower Zone and High Zone, evaluations conservatively do not include new storage, since the location and timing of storage is uncertain.

The future water system performance evaluation identifies necessary improvements to support MPMW's future projected water demands while meeting MPMW's recommended water system planning and design criteria.

8.4.1 Normal Operating Conditions

A steady-state (snapshot in time) hydraulic analysis was conducted using the hydraulic model to evaluate system performance under a future peak hour demand condition. As shown in Table 8-1, the peak hour demand for the future water service area was calculated to be approximately 8,100 gpm (12 mgd). For the Upper Zone, this analysis assumed the Sand Hill Reservoirs are 75 percent full and that the Sharon Heights Pump Station is off.

During a peak hour demand scenario, a minimum pressure of 40 psi must be maintained at service connections throughout the entire water system. For pipelines, it is recommended that maximum velocities should not exceed 4 feet per second (ft/s) in transmission pipelines or 5 ft/s in distribution pipelines during normal demand conditions, to help minimize energy (pumping) costs and excessive head loss due to undersized pipelines.

Results from the peak hour demand simulation indicate that the future water system could adequately meet MPMW's minimum pressure criterion of 40 psi at all customer services, except for the locations shown in red on Figures 8-1A and 8-1B. Results for the Lower Zone and High Pressure Zone are shown on Figure 8-1A, and indicated that pressures range from 40 psi to 80 psi in the Lower Zone and are 120 psi and higher in the High Pressure Zone. Pressures in the High Pressure zone are higher than 120 psi due to the unregulated connection to the SFPUC system.

In the Upper Zone (Figure 8-1B), pressures less than 40 psi occur immediately downstream of the Sand Hill Reservoir and along the reservoir outlet pipeline, where service elevations are within approximately 100 feet of the elevation of the water surface in the Sand Hill Reservoirs. The SLAC has a turnout on the reservoir outlet pipeline that includes a booster pump to provide flow at adequate pressure. All other locations in the Upper Zone range from 40 psi to 120 psi, depending on location and elevation. Since customer demands can be met with adequate pressure for all pressure zones, no improvements are required.

8.4.2 Fire Flow Conditions

To evaluate the future water system for fire flow conditions, InfoWater's "*Available Fire Flow Analysis*" tool was used to determine the available fire flow at a minimum residual pressure of 20 psi and a maximum velocity constraint of 12 ft/s. For the future system fire flow analysis, key junctions that represent hydrant locations were evaluated to determine the available flow that can be provided, while meeting the maximum day demand in the Upper Zone and a peak hour demand in the Lower and High Pressure Zones. The analysis assumed that storage reservoirs are 75 percent full and that the Sharon Heights Pump Station is off.

Figures 8-2A, 8-2B, 8-2C, and 8-2D summarize the available fire flow at each tested hydrant location while meeting the minimum residual pressure criterion of 20 psi. Figures 8-2A and 8-2B show results for the system with fire flow criteria based on non-sprinklered services. Non-sprinklered fire flow requirements range from 1000 gpm for single-family residential to 8000 gpm for multi-family residential, commercial, industrial and institutional uses. Figures 8-2C and 8-2D present results with fire flow criteria based on sprinklered services. For customers with sprinklers, fire flow requirements are 50 percent of requirements. On each of the figures, locations that meet the fire flow requirements are shown in green. Locations that don't meet fire flow requirements are shown in red. Available fire flow, in gpm, is also noted for locations that do not meet fire flow requirements.

Figures 8-2A and 8-2B indicate that there are numerous locations that don't meet the non-sprinklered fire flow criteria. These tend to be in locations where there are higher fire flow requirements and hydraulic constraints due to small-diameter pipelines, and/or areas where elevations are higher and static pressures are lower. Figures 8-2C and 8-2D show that the majority of locations meet sprinklered fire flow requirements. For the Lower and High Pressure Zones (Figure 8-2C), deficient areas are confined to areas where there are single feeds to an area, and the O'Brien Drive area in the Lower Zone, east of Willow Road, where there are small diameter pipelines supplying the area that constrain flow to the area. For the Upper Zone, there are isolated dead-end pipelines and/or small-diameter pipelines where fire flows are less than the 4,000 gpm criterion for multi-family residential, commercial, industrial and institutional land use required. However, all but one of these locations have flows are within 100 to 500 gpm of meeting the requirement.

Improvements were evaluated for the future system to improve fire flow. The analysis focused on meeting fire flow requirements using the sprinklered requirements, since new developments will be required to be sprinklered. Figure 8-3 shows improvement projects for the Lower Zone and High Pressure Zone, and the available fire flows after making improvements. No improvements were identified for the Upper Zone, since available fire flows are higher than sprinklered fire flow criteria in most locations, and only slightly less than criteria in the areas where sprinklered fire flow criteria are not met.

8.4.3 Water Quality Operations

To evaluate the future water quality of the system under the average day demand scenario, a water quality analysis was performed to determine the water age at various locations throughout the system. For the water age analysis, water entering the system is assumed to have a water age of zero. As water travels through the system or is detained in system storage, it ages.

Figures 8-4A and 8-4B summarize the maximum water age at each junction location under average day demands. In the Lower Zone (Figure 8-4A), the maximum water age is typically less than 24 hours (purple dots), with a few locations showing water age of 24 to 48 hours (light blue dots). The addition of a storage tank in the future would increase water age, but the tank would be a ground-level tank with a booster pump station, providing flexibility to operate storage to manage water quality.

As shown on upper right portion of Figure 8-4A, there is a 2.5-mile long pipeline that runs along the Highway 84 frontage road to the Dumbarton Bridge entrance, where there is a hydrant, and then the pipeline loops back to a PG&E electrical substation. The pipeline is a 12-inch diameter pipeline, and contains about 80,000 gallons of water. The water age is high due to the large volume of water in the pipeline and very limited usage most of the time. The model shows that the water age is greater than 120 hours (during normal operating conditions), and review of the results indicate that water would continue to age because of the very low demand at the substation.

MPMW confirmed that it is difficult to maintain a chlorine residual in this pipeline, and that it cannot easily, economically, or practically be flushed, due to the large volume of water that would need to be discharged. There are service meters at a City-owned pump station south of Highway 84, at the Dumbarton pier, and at the electrical substation. Based on review and discussion of options with MPMW, West Yost recommends that this pipeline be designated as a non-potable water fire-service pipeline, with a State Water Resources Control Board, Division of Drinking Water (DDW) approved cross-connection control assembly that separates it from the potable water system, and with appropriate signage at the pump station, Dumbarton pier and electrical substation to indicate that the water is non-potable.

A DDW-approved backflow prevention assembly should be installed at the point where the fire-service pipeline connects to MPMW's distribution system to provide the DDW-required separation of the non-potable fire-service pipeline from its potable water system.

MPMW should discuss with its DDW District Engineer whether DDW will require a permit amendment that documents that this non-potable fire-service pipeline is separated from its potable water distribution system by an appropriate backflow prevention assembly, or if this could be addressed and approved by DDW through its annual inspection report.

MPMW should amend its water system operating permit to indicate that its 12-inch diameter fire-service pipeline provides non-potable water service to toilet, sink, and other water service facilities at PG&E's substation and its pump station, that the new backflow prevention assembly will be inspected and tested annually, that appropriate signage about non-potable water being used at all restrooms and other locations, and that bottled water will be provided for personal consumption use at locations where there currently is potable water service.

For the water age analysis of the Upper Zone, Sand Hill Reservoirs were assumed to operate at lower levels, consistent with wintertime operations, with levels ranging from 8 feet to 12 feet. Results show that the maximum water age ranges from 72 hours to 96 hours, with a few locations where water age exceeds 120 hours. Water ages are generally higher in the Upper Zone because of the storage in the zone. MPMW's practice of operating at lower levels during the winter months when demands are low helps to reduce water age and maintain chlorine residual, and this practice should be continued. MPMW has also purchased mixers that will be installed at the reservoirs.

For dead end pipelines with very low demands, West Yost recommends installation of automated valves at blowoffs to periodically flush the pipeline if MPMW has particular locations where there are problems maintaining residual.

8.4.4 Emergency Operations

Emergency operations were evaluated for each zone, assuming loss of SFPUC supply, and for the Upper Zone, loss of the reservoirs. For the Lower Zone and High Pressure Zone, a hydraulic analysis was performed to evaluate meeting system demands from emergency wells. For the Upper Zone, calculations were prepared to evaluate duration of service under future average day demand conditions with the existing storage reservoirs available.

For the Lower Zone and High Pressure Zone analysis, all SFPUC turnouts were assumed to be out of service, with wells supplying the average day demand of 2,100 gpm. MPMW has not yet determined the siting of additional wells besides the one that has been installed at the Corporation Yard. West Yost reviewed potential sites identified in the Supplemental Emergency Water Supply Program, picking the Willow Oaks Park site, since it is closest to the existing well, to check that supply could be distributed to all areas of the Lower Zone and High Pressure Zone at adequate pressure.

Three check valves are also recommended to provide service during an outage: two check valves to interconnect the Lower Zone and High Pressure Zone at locations where there are currently normally closed valves, and one check valve on a normally closed valve that would connect the SRI service, which is currently directly served from the SFPUC turnout without pressure regulation, to the Lower Zone. Check valve connections at these locations, where normally closed valves separate the regulated Lower Zone and the unregulated High Pressure Zone or SRI service, would allow water from the Lower Zone to enter these areas, enabling continuous service in the event of an emergency. Under normal operations, the check valve would prevent water from the higher pressure unregulated zones from entering the Lower Zone.

Figure 8-5 shows results of the analysis. As the figure shows, pressures in the Lower Zone and High Pressure Zone range from 60 to 100 psi, depending on location. The High Pressure Zone and the SRI service would be served through the proposed check-valve locations, shown on the figure, which would interconnect them to the Lower Zone and provide service based on the operating gradient of the Lower Zone.

For the Upper Zone, the Sand Hill reservoirs are operated between 8 to 12 feet during the winter months, which corresponds to 1.8 MG to 3.0 MG of storage. The Upper Zone future average day demand is 901 gpm. Assuming that the reservoirs are at an operating level of 8 feet or 1.7 MG, they would be able to supply the zone for 32 hours under future average day demand conditions. Based on the bottom elevation of the reservoir of 474 feet msl, Upper Zone static pressures range from 50 to 132 psi, indicating that Upper Zone would have adequate pressure as long as there is water in the reservoirs.

In the event of an outage of the Sand Hill Reservoirs, the zone is supplied by the Sharon Heights Pump Station. The pump station includes fixed speed pumps, making it difficult to control system pressure if the reservoirs are offline. Installation of a variable frequency drive is recommended, to allow operation of a pump on system pressure, when the reservoirs are out of service.

8.5 SUMMARY OF RECOMMENDED IMPROVEMENTS FOR THE FUTURE WATER SYSTEM

Table 8-4 summarizes recommended improvements. The top portion of the table summarizes capacity improvements based on the facilities capacity analysis and hydraulic analysis. The middle portion of the table summarizes improvements based on the water quality analysis. The bottom portion of the table summarizes reliability improvements, based on improving system reliability during emergencies.

Table 8-4. Recommended Future Water Distribution System Improvements

CIP ID	Zone	Improvement Description	Location	Reason for Improvement
Capacity Improvements				
Pipeline Improvements				
CAP-01	High Pressure	2,030 feet of new 12-inch pipe	Along Haven Avenue west of 3585 Haven Avenue	Improves fire flow availability.
CAP-02	High Pressure	740 feet of replace 12-inch pipe	Along Chilco Street between Constitution Drive and Chilco Street	
CAP-03	Lower	600 feet of new 12-inch pipe	Along private easements between O'Brien Drive and alley south of O'Brien Drive west of 1330 Obrien Drive; Along private easements between O'Brien Drive and alley south of O'Brien Drive west of 1460 Obrien Drive	
CAP-04	Lower	2,110 feet of replace 12-inch pipe	Along O'Brien Drive between Willow Road and Kelly Court; Along private easement east of Willow Road and north of Ivy Drive	
CAP-05	Lower	360 feet of replace 8-inch pipe, 440 feet of replace 10-inch pipe, 440 feet of replace 12-inch pipe	Along Laurel Street West of Burgess PRV Station; along private easement west of Burgess PRV Station	
CAP-06	Lower	770 feet of replace 10-inch pipe	Within Corporate Yard	
Storage Improvements				
CAP-07	Lower	2.5 MG Storage Tank (partially buried)	TBD[b]	Provides system storage for operational, fire flow and emergency needs.
CAP-08	Lower	7.5 mgd (firm capacity) booster pump station and associated on-site back up generator for storage tank[a]		
Reliability Improvements				
REL-06	Lower	Conversion of Dumbarton pipeline (2.5 miles of 12-inch diameter pipeline) into a non-potable pipeline	Dumbarton Bridge	Cannot maintain water quality in large-diameter pipeline
REL-07	Lower, High Pressure, Upper	Installation of automated blowoffs at dead-end locations	System-Wide	Improve water quality
REL-08	Upper	Reservoir Mixers at Sand Hill Reservoirs to avoid reservoir stratification and improve water quality	Sand Hill Reservoirs	Improve water quality
REL-09	Lower	New well with a design flow of 1,500 gpm and dynamic head of 265 feet, 100 feet of 12-inch pipe	TBD[c]	Planned as part of the Supplemental Emergency Water Supply Project to provide emergency supply to Lower Zone.
REL-10	Lower	New Well required if REL-15 is unable to meet a design production of 1,500 gpm.	TBD[c]	Planned as part of the Supplemental Emergency Water Supply Project, only if two wells cannot supply program objective of 3,000 gpm
REL-11	Lower	One 10-inch check valve. Check valve assumed to be installed near the existing normally closed valve between the 10-inch bypass and the Burgess PRV station.	At Burgess PRV Station	SRI is served directly from the SFPUC Burgess turnout without pressure regulation. Replacing the existing normally closed valve with a check valve would interconnects Lower Zone to SRI if the SFPUC Burgess turnout is out of service. Under normal conditions, the check valve would prevent unregulated high pressure water from flowing into the Lower Zone.
REL-12	Lower, High Pressure	Two 12-inch check valves. Both check valves are assumed to be installed at existing normally closed valve locations.	One at intersection of Del Norte Avenue and Terminal Avenue; One at intersection of Del Norte Avenue and Market Place	The High Pressure Zone is served directly from the SFPUC Hill Turnout. Replacing the existing normally closed valves with check valves would Interconnect the Lower Zone and High Pressure Zone if the Hill turnout is out of service. Under normal conditions, the check valve would prevent unregulated hugh pressure water from flowing into the Lower Zone.
REL-13	Upper	Equip Sharon Heights Pump Station with VFD's to improve pressure management in Upper Zone during outage of Sand Hill Reservoirs.	Sharon Heights Pump Station	Improves pressure management in Upper Zone during outage of Sand Hill Reservoirs.

(a) Booster pump station capacity was assumed to be 7.5 mgd, capable of draining a 2.5 mgd tank in 8 hours.
(b) Storage Tank and Booster Pump station location unknown and additional siting evaluations are recommended to confirm size and locations of proposed future storage.
(c) For the purposes of the hydraulic evaluation, one new well location was assumed, near the intersection of Willow Road and Coleman Avenue. However, actual location is unknown, and groundwater well siting analyses and testing are required to determine the location and production capacity.

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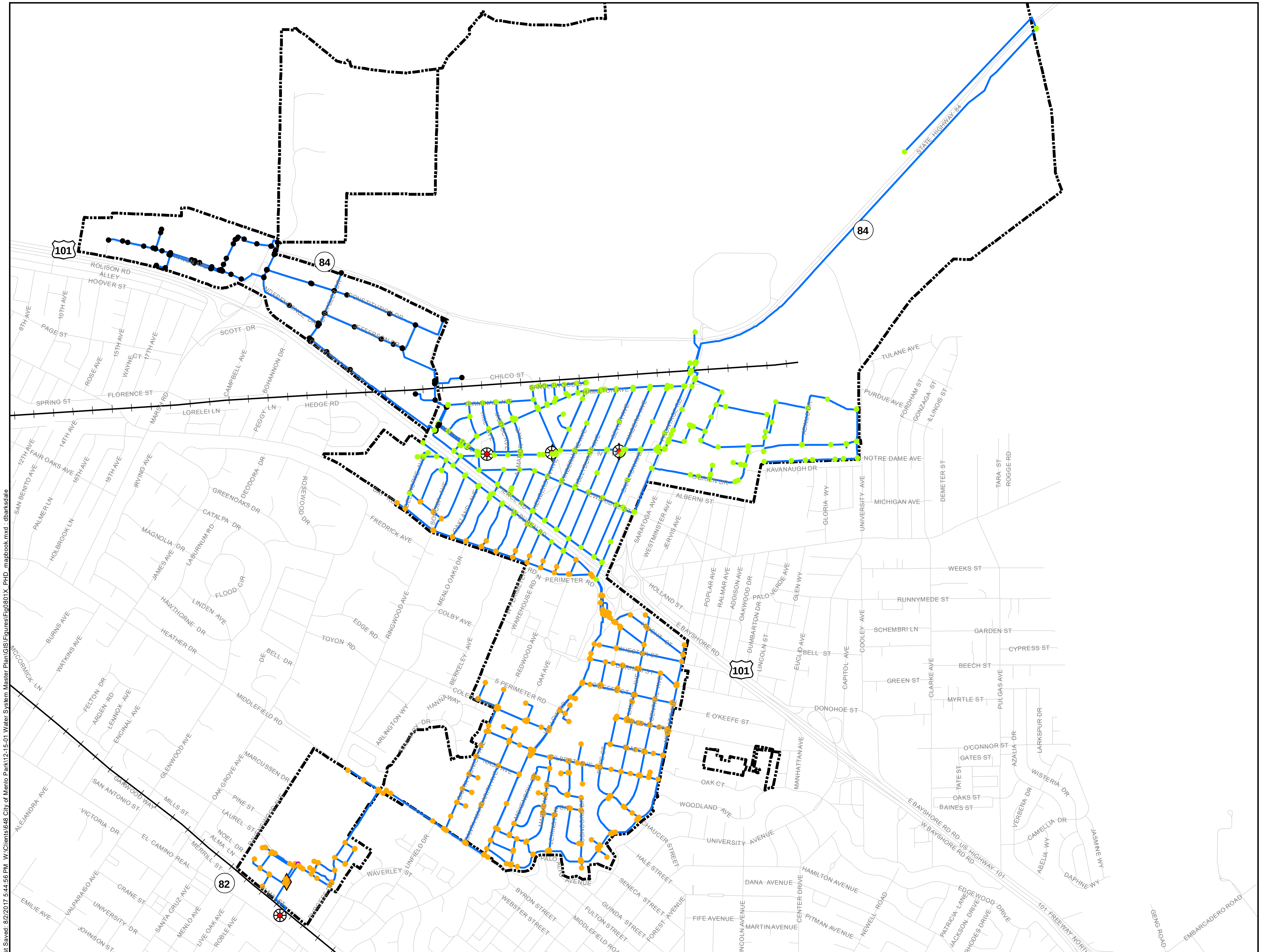

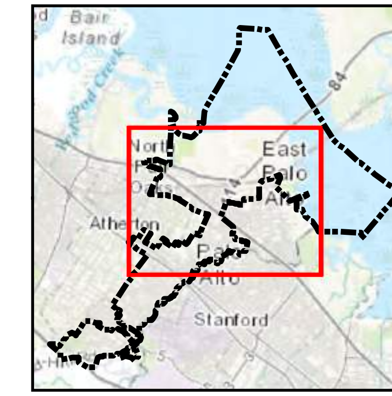

N

0 900 1,800

Scale in Feet

System Pressure

- 40 psi or less
- 40 psi to 60 psi
- 60 psi to 80 psi
- 80 psi to 100 psi
- 100 psi to 120 psi
- 120 psi or greater
- Sand Hill Reservoirs
- Sharon Heights Pump Station
- Pressure Reducing Valve Station
- SFPUC Turnout
- Existing Pipeline
- Water Service Area

Notes:
1. Future peak hour demand is equal to 11.7 mgd (8,126 gpm).
2. The Sand Hill Reservoirs was assumed to be 75 percent full.

CITY OF MENLO PARK

WEST YOST ASSOCIATES

Figure 8-1A

Future System Peak Hour Demand Results High Pressure & Lower Zones

Menlo Park Municipal Water
Water System Master Plan

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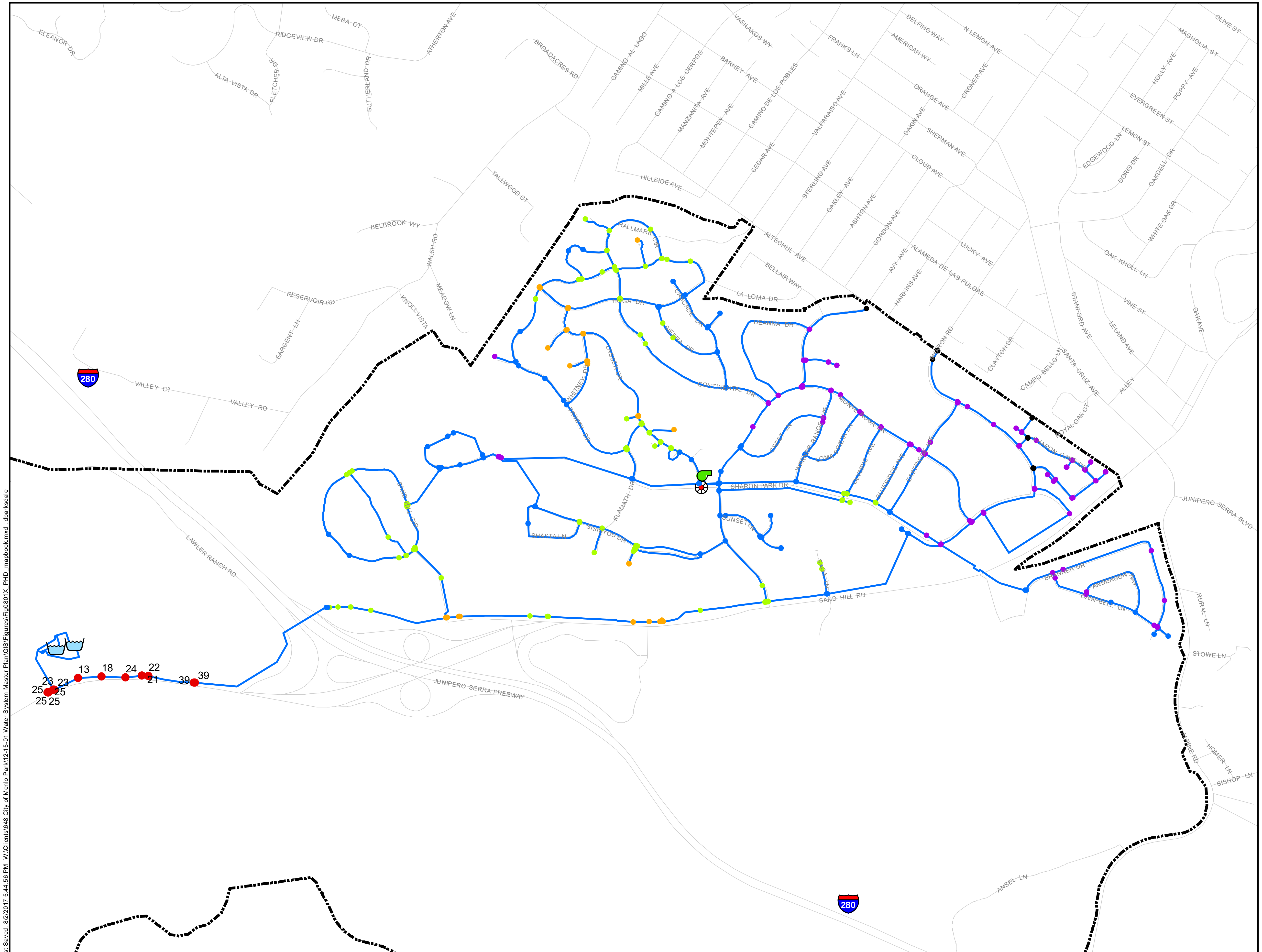

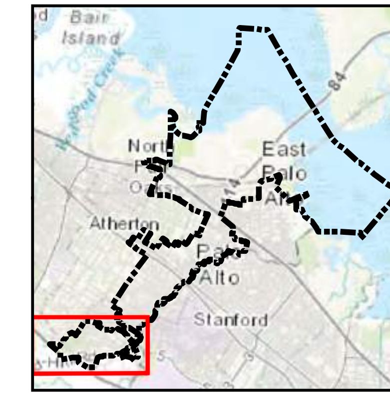

Scale in Feet: 0, 500, 1,000

System Pressure

- 40 psi or less
- 40 psi to 60 psi
- 60 psi to 80 psi
- 80 psi to 100 psi
- 100 psi to 120 psi
- 120 psi or greater
- Sand Hill Reservoirs
- Sharon Heights Pump Station
- Pressure Reducing Valve Station
- SFPUC Turnout
- Existing Pipeline
- Water Service Area

Notes:
1. Future peak hour demand is equal to 11.7 mgd (8,126 gpm).
2. The Sand Hill Reservoirs was assumed to be 75 percent full.

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Figure 8-1B

Future System Peak Hour Demand Results Upper Zone

Menlo Park Municipal Water
Water System Master Plan

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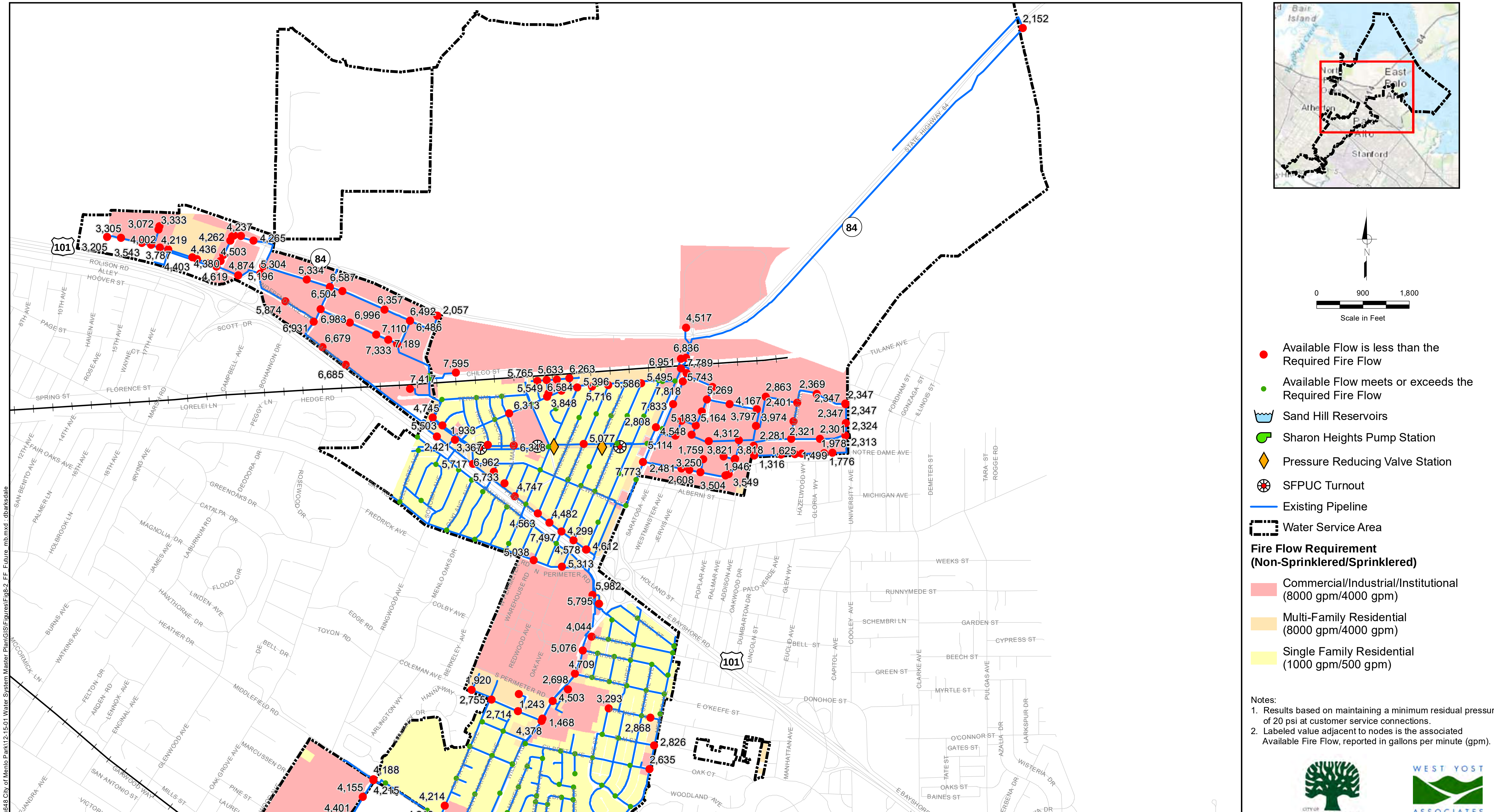

Figure 8-2A

Future System

Fire Flow Results under Non-Sprinklered Criteria for High Pressure & Lower Zones

Menlo Park Municipal Water
Water System Master Plan

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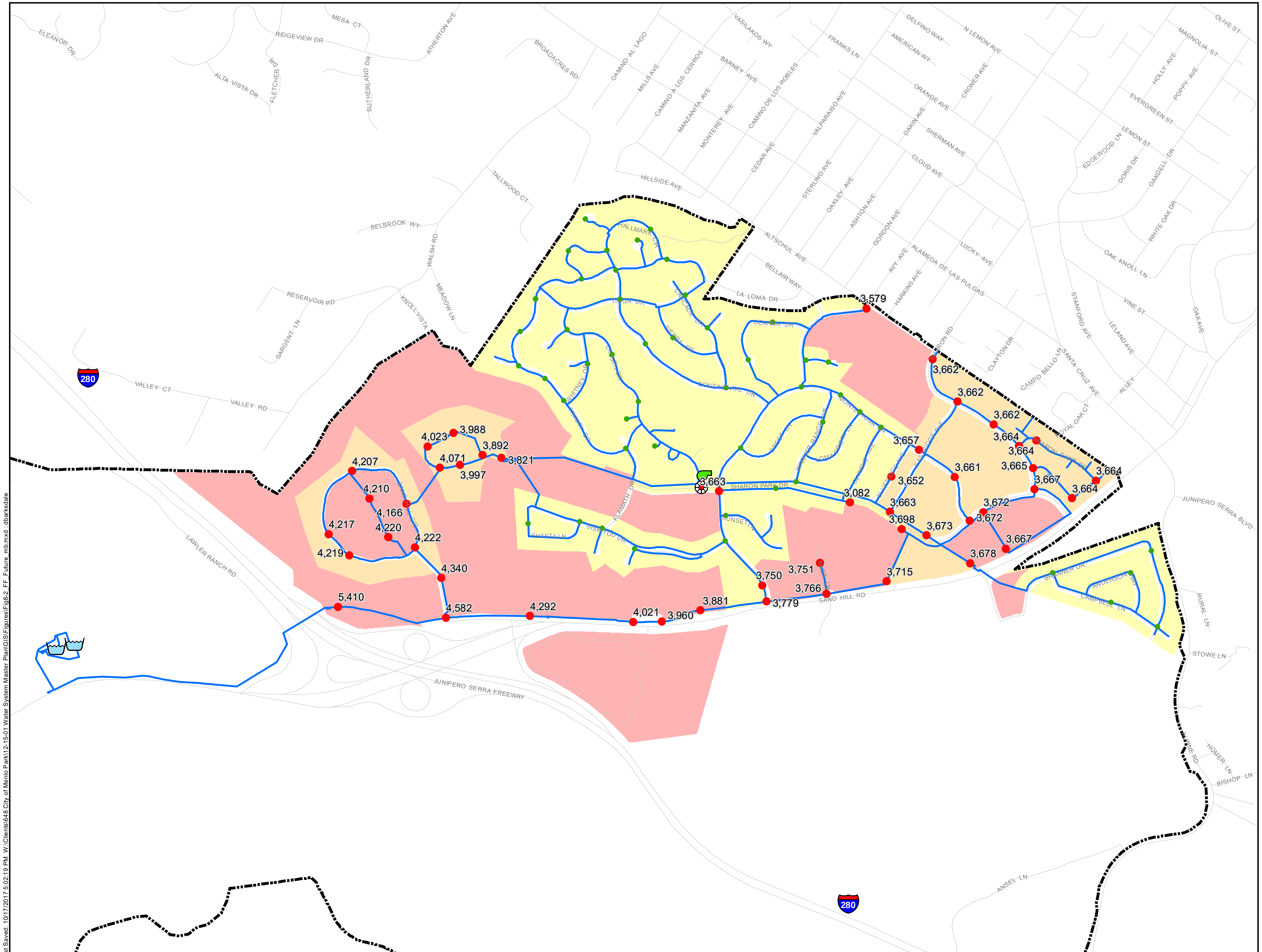

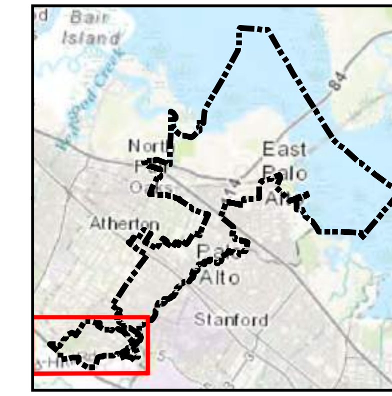

N

0 500 1,000
Scale in Feet

- Available Flow is less than the Required Fire Flow
- Available Flow meets or exceeds the Required Fire Flow
- Sand Hill Reservoirs
- Sharon Heights Pump Station
- Pressure Reducing Valve Station
- SFPUC Turnout
- Existing Pipeline
- Water Service Area

Fire Flow Requirement (Non-Sprinklered/Sprinklered)

- Commercial/Industrial/Institutional (8000 gpm/4000 gpm)
- Multi-Family Residential (8000 gpm/4000 gpm)
- Single Family Residential (1000 gpm/500 gpm)

Notes:
1. Results based on maintaining a minimum residual pressure of 20 psi at customer service connections.
2. Labeled value adjacent to nodes is the associated Available Fire Flow, reported in gallons per minute (gpm).

CITY OF MENLO PARK

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Figure 8-2B

Future System Fire Flow Results under Non-Sprinklered Criteria for Upper Zone

Menlo Park Municipal Water
Water System Master Plan

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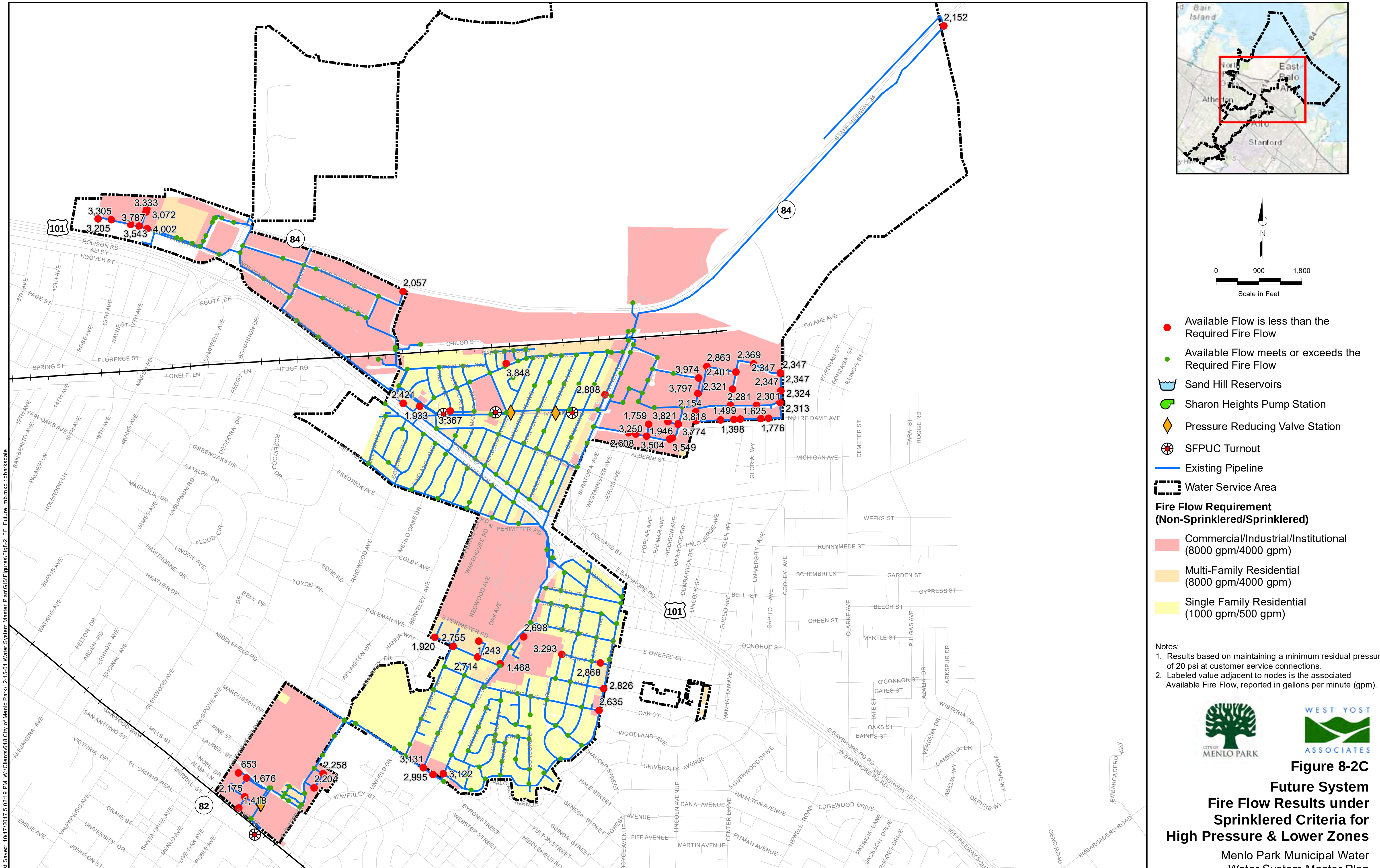

Figure 8-2C

Future System Fire Flow Results under Sprinklered Criteria for High Pressure & Lower Zones

Menlo Park Municipal Water
Water System Master Plan

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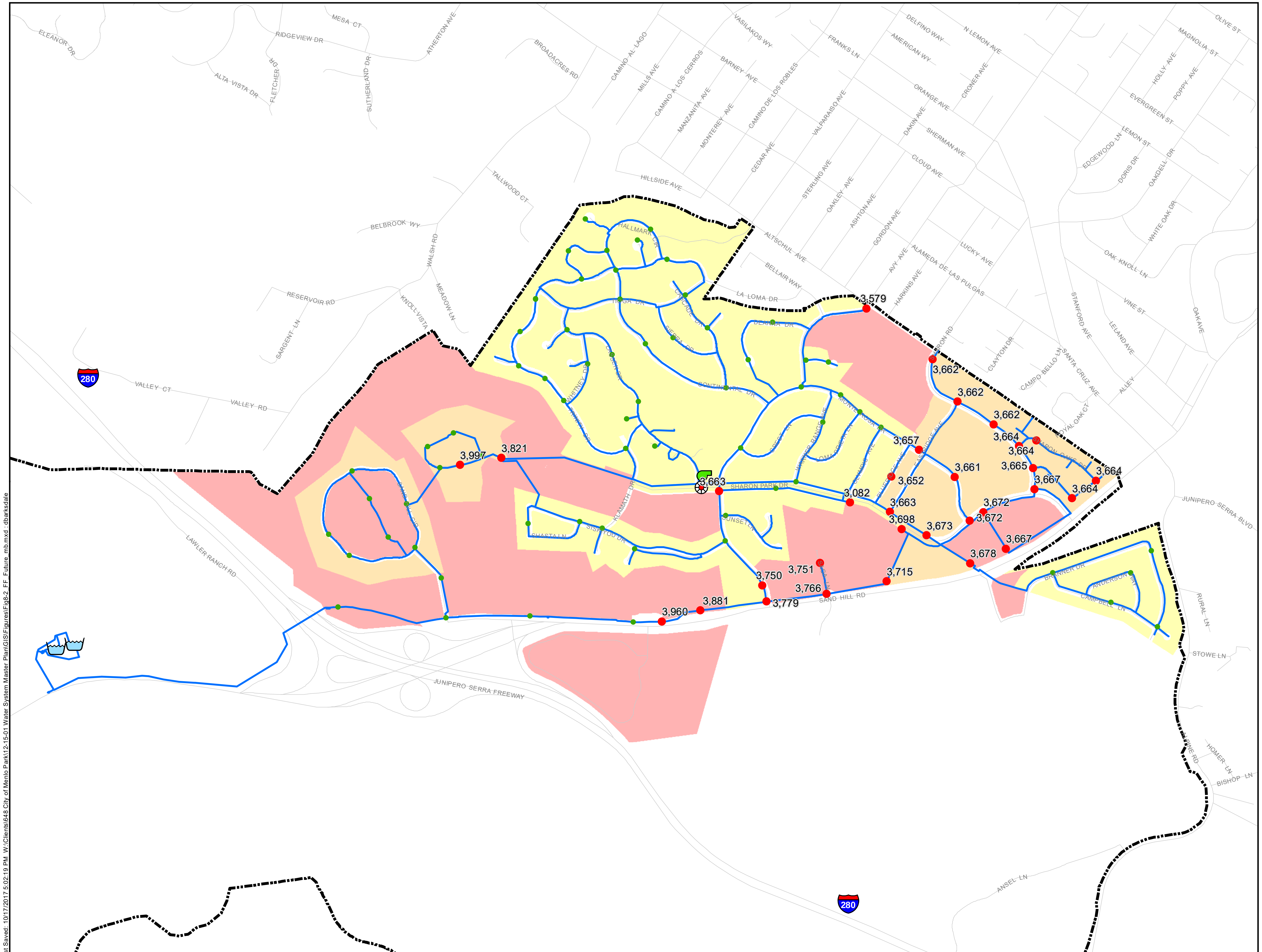

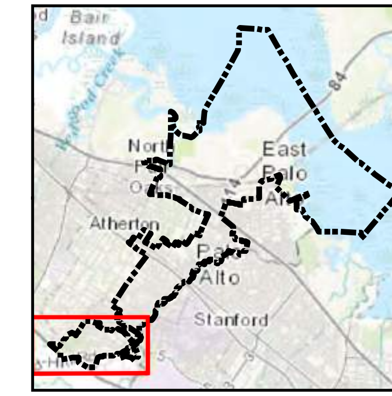

0 500 1,000

Scale in Feet

- Available Flow is less than the Required Fire Flow
- Available Flow meets or exceeds the Required Fire Flow
- Sand Hill Reservoirs
- Sharon Heights Pump Station
- Pressure Reducing Valve Station
- SFPUC Turnout
- Existing Pipeline
- Water Service Area

Fire Flow Requirement (Non-Sprinklered/Sprinklered)

- Commercial/Industrial/Institutional (8000 gpm/4000 gpm)
- Multi-Family Residential (8000 gpm/4000 gpm)
- Single Family Residential (1000 gpm/500 gpm)

Notes:
1. Results based on maintaining a minimum residual pressure of 20 psi at customer service connections.
2. Labeled value adjacent to nodes is the associated Available Fire Flow, reported in gallons per minute (gpm).

CITY OF MENLO PARK

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Figure 8-2D

Future System Fire Flow Results under Sprinklered Criteria for Upper Zone

Menlo Park Municipal Water
Water System Master Plan

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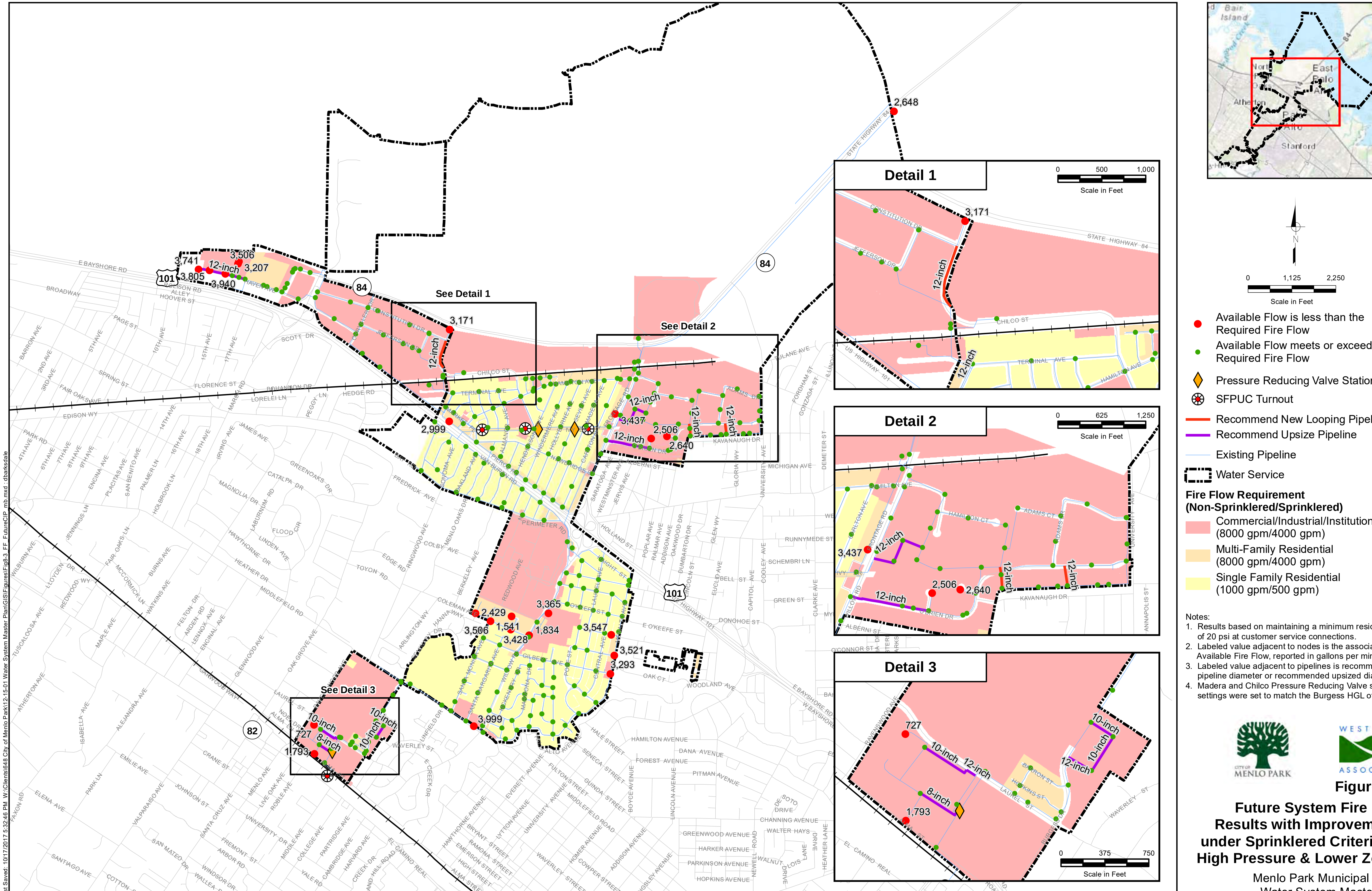

- Available Flow is less than the Required Fire Flow
- Available Flow meets or exceeds the Required Fire Flow
- Pressure Reducing Valve Station
- SFPUC Turnout
- Recommend New Looping Pipeline
- Recommend Upsize Pipeline
- Existing Pipeline
- Water Service

Fire Flow Requirement (Non-Sprinklered/Sprinklered)

- Commercial/Industrial/Institutional (8000 gpm/4000 gpm)
- Multi-Family Residential (8000 gpm/4000 gpm)
- Single Family Residential (1000 gpm/500 gpm)

Notes:

1. Results based on maintaining a minimum residual pressure of 20 psi at customer service connections.
2. Labeled value adjacent to nodes is the associated Available Fire Flow, reported in gallons per minute (gpm).
3. Labeled value adjacent to pipelines is recommended new pipeline diameter or recommended upsized diameter.
4. Madera and Chilco Pressure Reducing Valve station settings were set to match the Burgess HGL of 213 feet.

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Figure 8-3

Future System Fire Flow Results with Improvements under Sprinklered Criteria for High Pressure & Lower Zones

Menlo Park Municipal Water
Water System Master Plan

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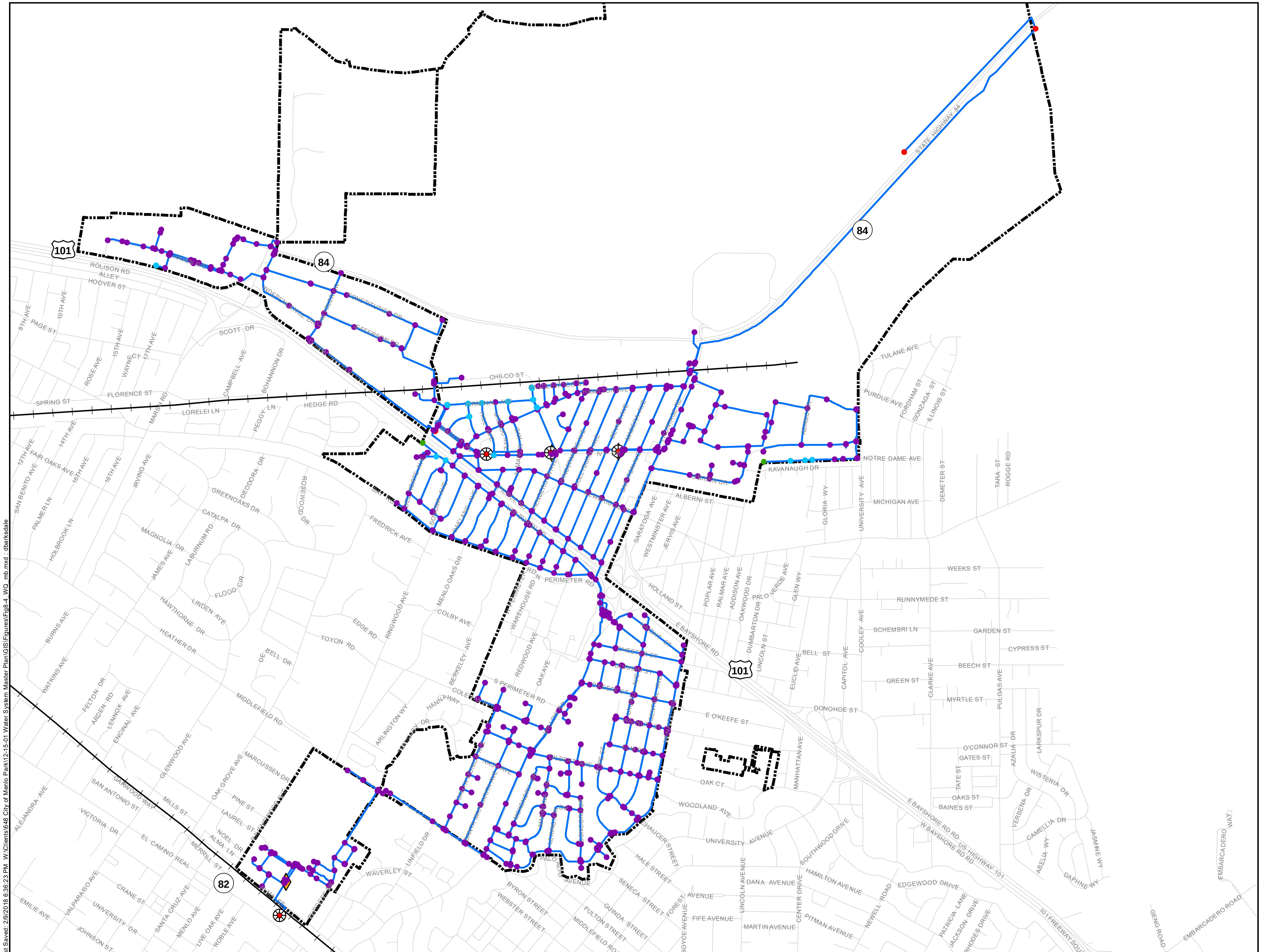

0 900 1,800

Scale in Feet

Max Water Age

- 0 hours < Water Age ≤ 24 hours
- 24 hours < Water Age ≤ 48 hours
- 48 hours < Water Age ≤ 72 hours
- 72 hours < Water Age ≤ 96 hours
- 96 hours < Water Age ≤ 120 hours
- Water Age > 120 hours
- Sand Hill Reservoirs
- Sharon Heights Pump Station
- Pressure Reducing Valve Station
- SFPUC Turnout
- Existing Pipeline
- Water Service Area

Notes:
1. Future average day demand is equal to 4.4 mgd (8,126 gpm).
2. The Sand Hill Reservoirs were assumed to be operating between 8 and 12 feet.

Figure 8-4A

Future System Average Day Demand Water Age Results High Pressure & Lower Zones

Menlo Park Municipal Water
Water System Master Plan

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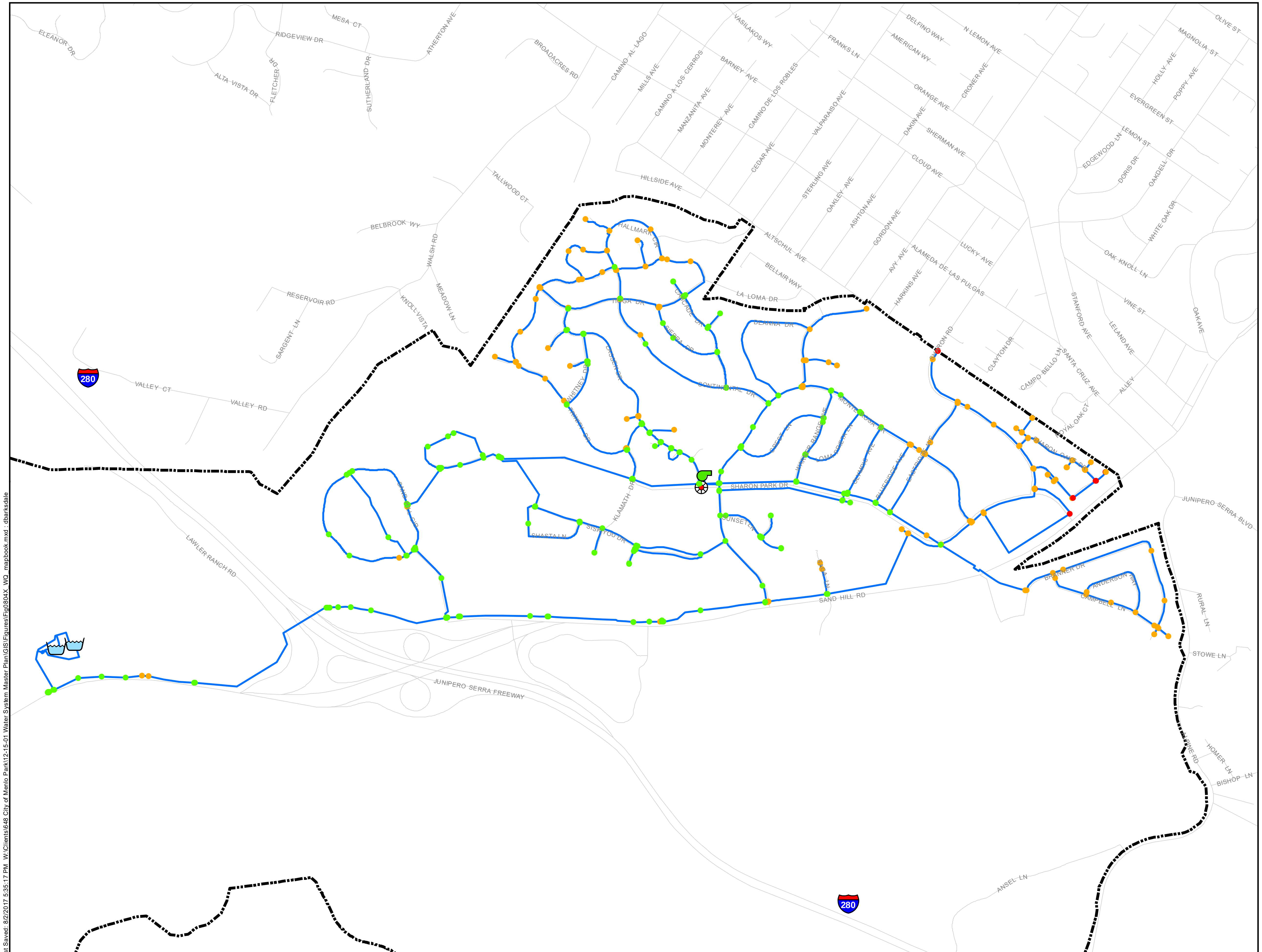

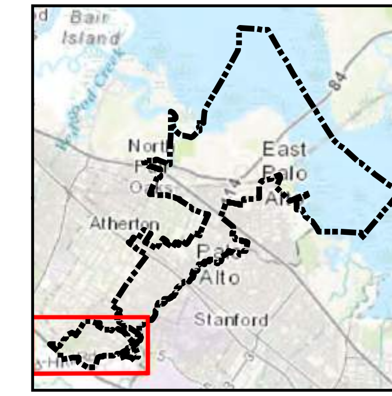

N

0 500 1,000

Scale in Feet

Max Water Age

- 0 hours < Water Age ≤ 24 hours
- 24 hours < Water Age ≤ 48 hours
- 48 hours < Water Age ≤ 72 hours
- 72 hours < Water Age ≤ 96 hours
- 96 hours < Water Age ≤ 120 hours
- Water Age > 120 hours
- Sand Hill Reservoirs
- Sharon Heights Pump Station
- Pressure Reducing Valve Station
- SFPUC Turnout
- Existing Pipeline
- Water Service Area

Notes:
1. Future average day demand is equal to 4.4 mgd (8,126 gpm).
2. The Sand Hill Reservoirs were assumed to be operating between 8 and 12 feet.

CITY OF MENLO PARK

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Figure 8-4B

Future System Average Day Demand Water Age Results Upper Zone

Menlo Park Municipal Water
Water System Master Plan

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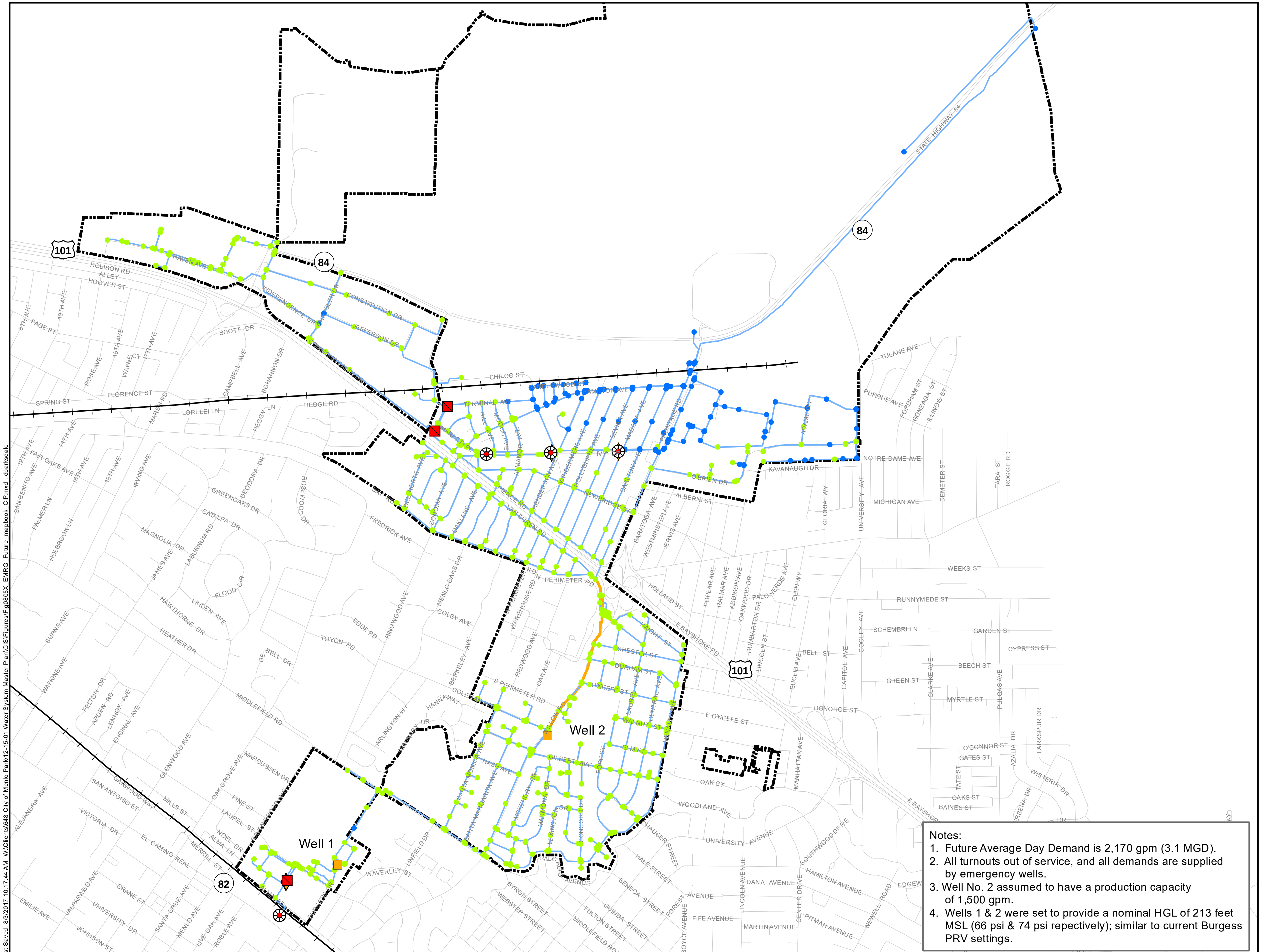
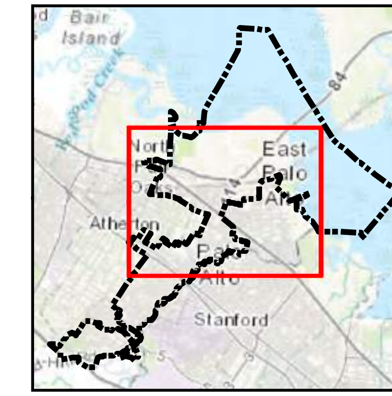


Notes:
1. Future Average Day Demand is 2,170 gpm (3.1 MGD).
2. All turnouts out of service, and all demands are supplied by emergency wells.
3. Well No. 2 assumed to have a production capacity of 1,500 gpm.
4. Wells 1 & 2 were set to provide a nominal HGL of 213 feet MSL (66 psi & 74 psi repectively); similar to current Burgess PRV settings.



N

0 900 1,800
Scale in Feet

- Proposed Check Valve
- Emergency Well
- Pressure Reducing Valve Station
- SFPUC Turnout

System Pressure
- 40 psi or less
- 40 psi to 60 psi
- 60 psi to 80 psi
- 80 psi to 100 psi
- 100 psi to 120 psi
- 120 psi or greater

Pipeline Velocity
- Less than 3 ft/s
- 3 ft/s to 4 ft/s
- Greater than 4 ft/s
- Water Service

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WEST YOST ASSOCIATES

Figure 8-5
Outage Scenario
Future Average Day
All Turnouts Out of Service
Menlo Park Municipal Water
Water System Master Plan

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CHAPTER 9
Recommended Capital Improvement Program

This chapter presents the recommended Capital Improvement Program (CIP) for the City's existing and future water system based on the evaluations described in Chapters 7 and 8 of this WSMP. This chapter also includes some recommendations identified as part of the O&M evaluation, and other improvements identified through discussion with MPMW staff. The chapter provides a summary of the recommended capital improvement projects, along with estimates of probable construction costs. Probable construction cost estimates are developed individually for each proposed improvement project.

It should be noted that the recommended CIP only identifies improvements at a Master Plan level and does not necessarily include all required on-site infrastructure, or provide design of improvements. Subsequent detailed design is required to determine the exact sizes and locations of these recommended improvements.

9.1 COST ASSUMPTIONS

Construction costs are presented in August 2017 dollars based on an Engineering News Record (ENR) Construction Cost Index (CCI) of 12,037 (San Francisco Average). Construction costs were developed based on bids on other water facilities for the design projects and from standard cost estimating guides. The total CIP cost includes mark-ups equal to 69 percent of the estimated base construction costs.[1] A design and construction contingency of 30 percent of the base construction costs is used. Markups for professional services during design and construction are 30 percent of the base construction costs plus the design and construction contingency, as listed below.

- Design and Construction Contingency: 30 percent
- Professional Services: 30 percent of the base construction cost plus the Design and Construction Contingency. Professional services are comprised of the following:

Design:	10 percent
Construction Management and Inspection:	10 percent
Permitting, Regulatory and CEQA Compliance:	5 percent
City Administration, Public Outreach, and Legal:	5 percent
Total:	**30 percent**

For this WSMP, it is assumed that recommended distribution system facilities will be developed in public rights-of-way or on public property; therefore, land acquisition costs have not been included. However, for the proposed tank a land lease/purchase cost was assumed using the same rate that the City pays for existing emergency well site. The construction cost estimates do not include costs for annual O&M. A complete description of the assumptions used in the development of the estimated probable construction costs is provided in Appendix F.

[1] The overall mark-up is compounded: [{Base Construction Cost (1.0) + Design and Construction Contingency (0.3) = 1.3} + Professional services (1.3 x 0.3 = 0.39)] = 1.69 x Base Construction Cost.

9.2 RECOMMENDED CAPITAL IMPROVEMENT PROGRAM

The overall recommended water system capital improvement projects are listed in Table 9-1 and shown on Figure 9-1A and Figure 9-1B. The recommended CIP has a total capital cost of just over $89M. Recommended capital improvement projects are categorized by improvement type (i.e., capacity, reliability, rehabilitation and replacement, and other). In addition, because of the magnitude of the CIP, projects have been prioritized into very high, high and medium priority, which can be used to evaluate implementation timing of projects based on affordability to the MPMW. Priorities were assigned based on perceived risk of not implementing particular projects and are summarized in the sections below.

9.2.1 Very High Priority Improvements

Very high priority projects total $53M in capital costs and include the following:

- Continue to implement MPMW's Emergency Well Supply Program;
- Continue to implement MPMW's pipeline replacement program, increasing the level of spending to at least $1.6M per year, construction costs (with contingencies) in current dollars;
- Implement emergency metered interconnections with Palo Alto and Cal Water;
- Complete Seismic evaluation of Sand Hill Reservoirs;
- Equip the Lower Zone at locations near SRI and the High Pressure Zone with check valves to improve emergency preparedness;
- Complete post-earthquake planning documents to improve earthquake readiness;
- Develop and acquire equipment for re-fueling generators following an earthquake;
- Implement a non-structural anchorage program as part of the regular maintenance budget;
- Develop and update MPMW's Standard Details and Design Guidelines; and
- Install reservoir mixers at the Sand Hill Reservoirs to avoid stratification and improve water quality.

These projects are deemed very high priority because they improve system resiliency, address aging facilities and improve MPMW's earthquake planning and response, and there is a higher risk if improvements are not implemented. West Yost recommends funding the pipeline replacement program at $1.6 million (M) per year ($1.2M base construction cost plus 30 percent contingency), which over the WSMP timeframe (through 2040), would fund projects in the Medium-High and High-Risk categories. This is about twice the current rate of pipeline replacement funding by MPMW. It is estimated that $1.6M per year would fund approximately 0.6 to 0.9 miles per year, depending on the diameter and ease of construction.

Table 9-1. Recommended Water Distribution System Capital Improvement Program[a]

CIP ID	Zone	Improvement Type	Reason for Improvement	Improvement Description	Location	Priority	Estimated Construction Cost[b]	Capital Cost (includes mark-ups)[c]
Capacity Improvements								
Fire Flow Improvements								
CAP-01	High Pressure	Fire Flow	Improvements listed in this section are needed to address fire flow deficiencies identified in the hydraulic analysis	2,030 feet of new 12-inch pipe	Along Haven Avenue west of 3585 Haven Avenue	High	$975,000	$1,268,000
CAP-02	High Pressure	Fire Flow		740 feet of replace 12-inch pipe	Along Chilco Street between Constitution Drive and Chilco Street	High	$354,000	$460,000
CAP-03	Lower	Fire Flow		600 feet of new 12-inch pipe	Along private easements between O'Brien Drive and alley south of O'Brien Drive west of 1330 Obrien Drive; Along private easements between O'Brien Drive and alley south of O'Brien Drive west of 1460 Obrien Drive	High	$285,000	$371,000
CAP-04	Lower	Fire Flow		2,110 feet of replace 12-inch pipe	Along O'Brien Drive between Willow Road and Kelly Court; Along private easement east of Willow Road and north of Ivy Drive	High	$1,014,000	$1,318,000
CAP-05	Lower	Fire Flow		360 feet of replace 8-inch pipe, 440 feet of replace 10-inch pipe, 440 feet of replace 12-inch pipe	Along Laurel Street West of Burgess PRV Station; along private easement west of Burgess PRV Station	High	$508,000	$660,000
CAP-06	Lower	Fire Flow		770 feet of replace 10-inch pipe	Within Corporate Yard	High	$318,000	$413,000
						Subtotal	$3,454,000	$4,490,000
Storage Improvements								
CAP-07	Lower	Storage	Tank and booster pump station improvements are recommended to meet operational, emergency, and fire flow storage needs of the Lower and High Pressure Zone	2.5 MG Storage Tank (partially buried)[d]	TBD[f]	Medium	$10,948,000	$14,233,000
CAP-08	Lower	Storage		7.5 mgd (firm capacity) booster pump station and associated on-site back up generator for storage tank[e]		Medium	$3,272,000	$4,253,000
						Subtotal	$14,220,000	$18,486,000
						Total Capacity Improvements	**$17,674,000**	**$22,976,000**
Reliability Improvements								
REL-01	Upper	Reliability Improvement	Mitigate seismic and geotechnical hazards. Specific project dependent on findings of Project REL-07	Upgrade/replace wood roofs on Sand Hill Reservoirs and mitigate geotechnical concerns. Value is a placeholder budget and should be revised with the findings from MISC-03[g]	Sand Hill Reservoirs	High	$3,900,000	$5,070,000
REL-02	Lower, High Pressure, Upper	Reliability Improvement	Mitigate seismic hazard.	Implement a non-structural anchorage program as part of the regular maintenance budget	System-Wide	Very High	$20,000	$26,000
REL-03	Lower	Reliability Improvement	Improves emergency supply reliability	New metered interconnection with Cal Water at the Alma Street Crossing. Project assumes an estimated 2,000 LF of 12-inch pipeline, with a portion within a new pedestrian bridge, and meter within a vault.	At the intersection of El Camino Real and Middle Avenue	Very High	$1,112,000	$1,500,000
REL-04	Lower	Reliability Improvement	Improves emergency supply reliability	New metered interconnection with City of Palo Alto at the Pope Chaucer Bridge (San Francisquito Creek). Project assumes an estimated 250 LF of new 12-inch pipeline, all assumed to be within a new bridge, and a meter within a vault	Along Chaucer Street, between Woodland and Palo Alto Avenues.	Very High	$228,000	$297,000

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Table 9-1. Recommended Water Distribution System Capital Improvement Program[a]

CIP ID	Zone	Improvement Type	Reason for Improvement	Improvement Description	Location	Priority	Estimated Construction Cost[b]	Capital Cost (includes mark-ups)[c]
REL-05	Lower	Reliability Improvement	Allows more use of Chilco and Madera PRV stations, with less reliance on Burgess PRV station.	Implement a residential/commercial pressure regulator program in the lower zone to help keep customer service pressures from exceeding 80 psi, allowing Chilco and Madera pressure regulating station settings to be set equal to the Burgess PRV station[h]	Various	High	$1,872,000	$2,434,000
REL-06	Lower Zone	Reliability Improvement	Cannot maintain water quality in large-diameter pipeline	Conversion of Dumbarton pipeline (12-inch) into a non-potable pipeline	Dumbarton Bridge	High	$100,000	$130,000
REL-07	Lower, High Pressure, Upper	Reliability Improvement	Improve water quality	Installation of automated blowoffs at dead-end locations	System-Wide	High	$150,000	$195,000
REL-08	Upper	Reliability Improvement	Improve water quality	Reservoir Mixers at Sand Hill Reservoirs to avoid reservoir stratification and improve water quality	Sand Hill Reservoirs	Very High	$120,000	$156,000
REL-09	Lower	Reliability Improvement	Planned as part of the Supplemental Emergency Water Supply Project to provide emergency supply to Lower Zone.	New well with a design flow of 1,500 gpm and dynamic head of 265 feet, 100 feet of 12-inch pipe	TBD[i]	Very High	$3,295,000	$4,284,000
REL-10	Lower	Reliability Improvement	Planned as part of the Supplemental Emergency Water Supply Project, only if two wells cannot supply program objective of 3,000 gpm	New Well required if REL-01 is unable to meet a design production of 1,500 gpm.	TBD[i]	Very High	$3,295,000	$4,284,000
REL-11	Lower	Reliability Improvement	SRI is served directly from the SFPUC Burgess turnout without pressure regulation. Replacing the existing normally closed valve with a check valve would interconnects Lower Zone to SRI if the SFPUC Burgess turnout is out of service. Under normal conditions, the check valve would prevent unregulated high pressure water from flowing into the Lower Zone.	One 10-inch check valve, required to be able to provide supply from the Lower Zone to SRI In the event that the Burgess SFPUC turnout is out of service. Check valve assumed to be installed near the existing normally closed valve between the 10-inch bypass and the Burgess PRV station.	At Burgess PRV Station	Very High	$65,000	$85,000
REL-12	High Pressure	Reliability Improvement	The High Pressure Zone is served directly from the SFPUC Hill Turnout. Replacing the existing normally closed valves with check valves would Interconnect the Lower Zone and High Pressure Zone if the Hill turnout is out of service. Under normal conditions, the check valve would prevent unregulated hugh pressure water from flowing into the Lower Zone.	Two 12-inch check valve, required to be able to provide supply from the Lower Zone if the Hill SFPUC turnout is out of service. Both check valves are assumed to be installed at existing normally closed valve locations.	One at intersection of Del Norte Avenue and Terminal Avenue; One at intersection of Del Norte Avenue and Market Place	Very High	$130,000	$169,000
REL-13	Upper	Reliability Improvement	Improves pressure management in Upper Zone during outage of Sand Hill Reservoirs.	Equip Sharon Heights Pump Station with VFD's to improve pressure management in Upper Zone	Sharon Heights Pump Station	Medium	$195,000	$254,000
						Total Reliability Improvements	**$14,482,000**	**$18,884,000**

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Table 9-1. Recommended Water Distribution System Capital Improvement Program[(a)]								
CIP ID	Zone	Improvement Type	Reason for Improvement	Improvement Description	Location	Priority	Estimated Construction Cost[(b)]	Capital Cost (includes mark-ups)[(c)]
Rehabilitation and Replacement Improvements								
RR-01	Lower, High Pressure, Upper	Program	Needed to maintain and improve the system. Pipelines identified in the Seismic Vulnerability Assessment are targeted as highest priority. As part of this program, MPMW should also identify opportunities to re-locate pipelines on private property to current rights-of-way	Pipeline replacement program, budgeted at $1.6M/year (Constructions cost with contingencies in current dollars, or $2.0M/yr in capital costs in current dollars) from 2018 through 2040. Capacity projects to improve fire flow shown above ($3.45M) are budgeted separately, but assumed to be part of this program. Therefore, remaining overall cost equals: [$1.6M/year x 23 years] - $3.45M	System-Wide, with focus on pipelines identified in Seismic Vulnerability Assessment and Capacity Evaluation as Highest Priority	Very High	$32,426,000	$42,150,000
					Total Rehabilitation and Replacement Improvements		**$32,426,000**	**$42,150,000**
Other System Improvements and Studies								
MISC-01	Lower, High Pressure, Upper	Other	Refines information for pipeline replacements to address seismic hazards.	Conduct pipeline hazard assessment (including field survey of geologic conditions along critical pipeline segments, review of boreholes, update liquefaction and landslide models)[(g)]	System-Wide	Medium	$50,000	$65,000
MISC-02	Lower, High Pressure, Upper	Other	Refine information for pipeline replacements to address seismic hazards.	Update Pipeline analysis based on updated hazard assessment[(g)]	System-Wide	Medium	$20,000	$26,000
MISC-03	Upper	Other	Addresses current codes which are more stringent than codes in place when structures were designed.	Conduct a structural, geotechnical, and seismic evaluation of Sand Hill Reservoir site[(g)]	Sand Hill Reservoirs	Very High	$60,000	$78,000
MISC-04	--	Other	Assess condition and identify retrofit needs to mitigate seismic hazards.	Conduct evaluation of Maintenance Building[(g)]	Burgess Drive	Medium	$20,000	$26,000
MISC-05	Lower, High Pressure, Upper	Other	Provide plan for operational response and recovery following earthquake	Develop post earthquake operational and recovery plan[(g)]	System-Wide	Very High	$40,000	$52,000
MISC-06	Lower, High Pressure, Upper	Other	Specific recommendations to be developed in operational and recovery plans.	Develop a plan and acquire equipment for re-fueling generators following an earthquake	System-Wide	Very High	$50,000	$65,000
MISC-07	--	Other	MPMW is currently developing standard details and design guidelines. This project should incorporate seismic design procedures or reference ASCE manual of practice for seismic design of water and sewer pipelines.	Develop Standard Details and Design Guidelines	System-Wide	Very High	$50,000	$65,000
MISC-08	Lower, High Pressure, Upper	Other	Replace aging meters, facilitate data collection and monitoring, reduce water loss.	Meter Replacement/Enhancement Program (assumes full system upgrade to AMI)[(k)]	System-Wide	High	$3,475,183	$4,518,000
MISC-09	Lower and High Pressure	Other	Improve system monitoring	Install pressure monitors and connect all turnouts to SCADA System	At Burgess, Chilco, Madera and Hill turnouts	Medium	$780,000	$1,014,000
MISC-10	Lower, High Pressure, Upper	Other	Protects system from cross-contamination.	Continued Implementation of the Backflow Prevention Program	System-Wide	Underway	--	--
MISC-11	--	Other	Increase sustainability of potable water supply.	Conduct further recycled water studies for continued development of this program	System-Wide	Medium	$150,000	$195,000
MISC-12	Lower	Other	Provides MPMW with a means for metering water that may need to be supplied to East Palo Alto in the event of an emergency.	Construct metered connections and replace valves at interties with East Palo Alto	University Avenue, O'Brien Drive and Willow Road	Medium	Cost to be Determined	

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Table 9-1. Recommended Water Distribution System Capital Improvement Program[a]

CIP ID	Zone	Improvement Type	Reason for Improvement	Improvement Description	Location	Priority	Estimated Construction Cost[b]	Capital Cost (includes mark-ups)[c]
MISC-13	Lower, High Pressure, Upper	Program	State requirement to eliminate piping and fittings in water service connections that contain lead, if found in the distribution system.	Development of a Lead Service Replacement Program	System-Wide	Very High	Cost to be Determined	
MISC-14	Lower, High Pressure, Upper	Other	Provides MPMW with a roadmap for future capital expenditures in an effort uphold customer service by making targeted improvements to assets that are most critical in function or condition.	Development of an Asset Management Program	System-Wide	Medium	$150,000	$195,000
						Total Other System Improvements	**$4,845,183**	**$6,299,000**
						TOTAL CAPITAL IMPROVEMENT PROGRAM	**$69,427,183**	**$90,309,000**
						Very High Priority	**$40,891,000**	**$53,211,000**
						High Priority	**$12,951,183**	**$16,837,000**
						Medium Priority	**$15,585,000**	**$20,261,000**
						Total	**$69,427,183**	**$90,309,000**

(a) Costs shown are based on the August 2017 San Francisco ENR CCI of 12,037 and are rounded to nearest $1,000.

(b) Costs include mark-ups equal to 30 percent (Base Construction Costs plus Construction Contingency).

(c) Costs include mark-ups equal to 69 percent (Base Construction Costs plus Construction Contingency: 30 percent and; Professional Services: 30 percent of Base Construction Cost plus Contingency).

(d) Costs for the proposed tank include a land purchase/lease cost (to be purchased from the City) totaling $4.6M, which is based on the land lease price of the existing emergency well ($105/sq. ft.) site and assumes a one-acre site is required.

(e) Booster pump station capacity was assumed to be 7.5 mgd, capable of draining a 2.5 mgd tank in 8 hours.

(f) Storage Tank and Booster Pump station location unknown. Additional siting evaluations are recommended to confirm size and locations of proposed future storage.

(g) Costs directly from Vulnerability Assessment and do not include additional contingency. However, Capital Costs mark-ups are equal to 30 percent to budget staff time to implement improvement.

(h) Assumes 1,800 meter connection retrofits at $800 each.

(i) From Vulnerability Assessment.

(j) For the purposes of the hydraulic evaluation, the new well location was assumed to be near the intersection of Willow Road and Coleman Avenue.
However, actual location is unknown, and groundwater well siting analyses and testing are required to determine the location and production capacity (which may result in two wells being needed).

(k) Costs directly from Advanced Meter Infrastructure Evaluation TM (West Yost, October 2017) and includes the software cost of $25,000 per year through buildout (i.e., through 2040 or 23 years), shown in current dollars (i.e. 23 years x $25,000/yr).

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9.2.2 High Priority Improvements

High priority projects total $16M in capital costs and include the following:

- Pipeline improvements to improve fire flow capacity;
- Upgrade wood roofs on Sand Hill Reservoirs and mitigate geotechnical concerns;
- Residential/commercial pressure regulator program for Lower Zone;
- Conversion of 12-inch diameter Dumbarton Pipeline to non-potable pipeline;
- Installation of automated blow-offs to improve water quality at dead end main locations; and
- Meter replacement/enhancement program.

These projects are also important to improve system resiliency, provide more system operational reliability and flexibility, and address aging equipment. These projects should also be prioritized and implemented, as funding permits.

9.2.3 Medium Priority Improvements

Medium priority projects total $20M in capital costs and include the following:

- 2.5 MG storage reservoir and associated 7.5 mgd booster pump station in Lower Zone;
- Equip the Sharon Heights booster pump station with VFD’s;
- Update pipeline hazard assessment and re-analyze pipeline projects;
- Conduct seismic evaluation of maintenance building;
- Install pressure monitors and connect PRVs to system SCADA;
- Conduct further recycled water studies to further implement this program;
- Construct metered connections at locations where MPMW is currently intertied with East Palo Alto;
- Develop a Lead Service Replacement Program; and
- Develop an Asset Management Program.

These are projects that are generally considered to be medium priority because other higher priority projects are being implemented that help to meet these goals, and/or the consequence of not implementing these projects has less risk.

For example, storage in the Lower Zone is listed as lower priority because MPMW is currently focusing on implementation of the Emergency Water Supply Program, which provides reliable supply during an emergency, in which SFPUC water would be unavailable. Without storage, MPMW does not have the means to isolate the Lower and High Pressure Zone from the SFPUC in the event of a water quality incident, such as happened in March 2015, when SFPUC cross-connected its potable supply with a raw water supply source. However, the likelihood of this type of incident is considered low. However, MPMW should also consider implementing these projects as funding permits.

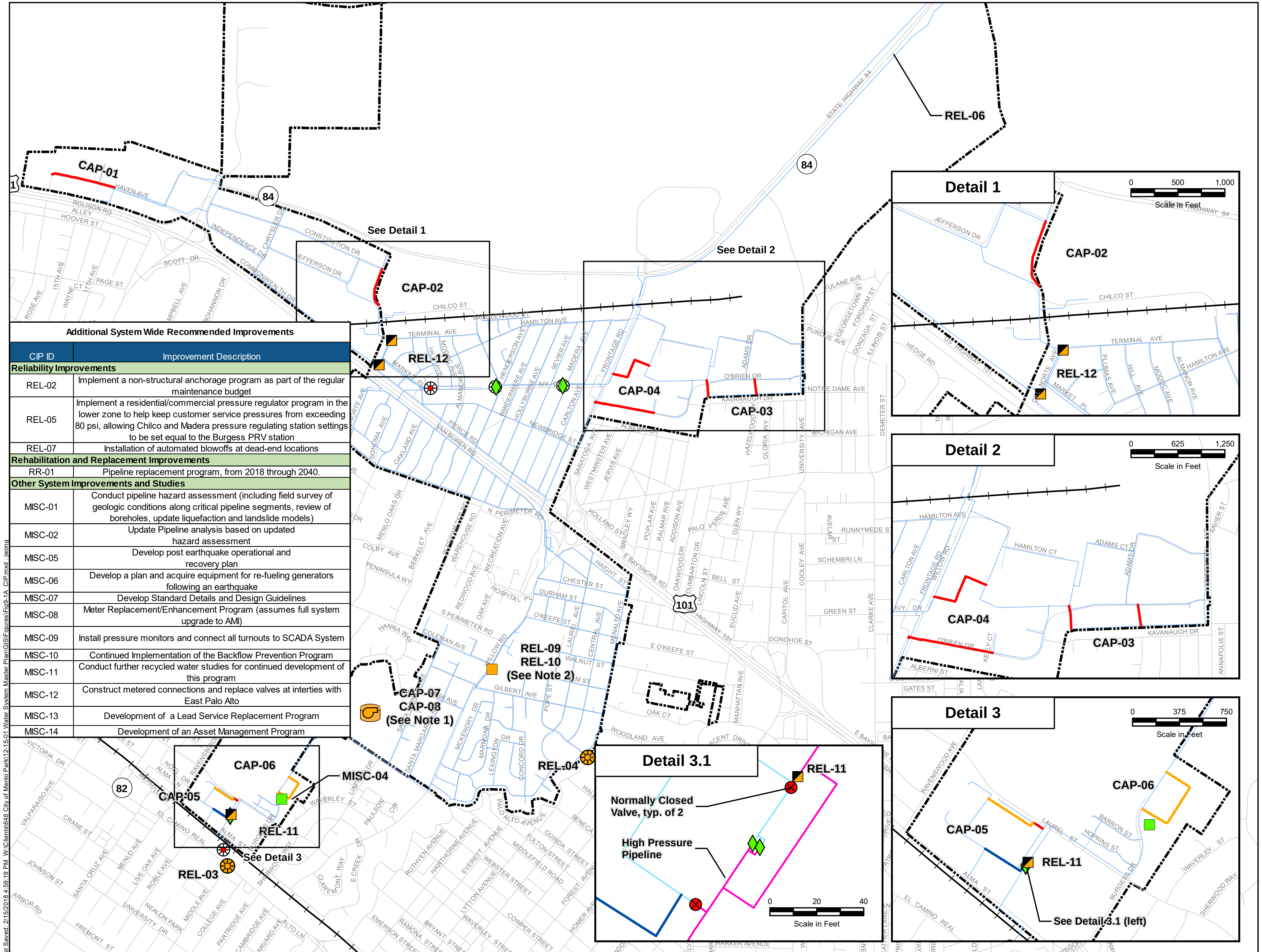
9.2.4 Summary of Overall Capital Improvement Costs

Table 9-2 summarizes the planning-level capital costs estimates by improvement type and priority. As previously noted, the total CIP cost is estimated to be $90 million. Approximately $53M, or approximately 60 percent of the overall CIP, is required to address improvements prioritized as very high priority. Of this amount, approximately $42M, or approximately 47 percent of the overall CIP, is required to rehabilitate and replace aging pipelines throughout the water service area.

Table 9-2. Summary of Capital Improvement Program Capital Costs by Priority and Improvement Type[a]

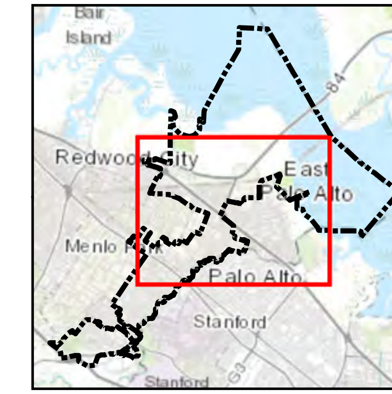
	Priority			
Improvement Type	Very High	High	Medium	Total
Capacity	$0.00	$4.49	$18.49	**$22.98**
Reliability	$10.80	$7.83	$0.25	**$18.88**
Rehabilitation and Replacement	$42.15	$0.00	$0.00	**$42.15**
Other	$0.26	$4.52	$1.52	**$6.30**
Total	**$53.21**	**$16.84**	**$20.26**	**$90.31**

[a] Capital costs are presented in millions.



Additional System Wide Recommended Improvements

CIP ID	Improvement Description
Reliability Improvements	
REL-02	Implement a non-structural anchorage program as part of the regular maintenance budget
REL-05	Implement a residential/commercial pressure regulator program in the lower zone to help keep customer service pressures from exceeding 80 psi, allowing Chilco and Madera pressure regulating station settings to be set equal to the Burgess PRV station
REL-07	Installation of automated blowoffs at dead-end locations
Rehabilitation and Replacement Improvements	
RR-01	Pipeline replacement program, from 2018 through 2040.
Other System Improvements and Studies	
MISC-01	Conduct pipeline hazard assessment (including field survey of geologic conditions along critical pipeline segments, review of boreholes, update liquefaction and landslide models)
MISC-02	Update Pipeline analysis based on updated hazard assessment
MISC-05	Develop post earthquake operational and recovery plan
MISC-06	Develop a plan and acquire equipment for re-fueling generators following an earthquake
MISC-07	Develop Standard Details and Design Guidelines
MISC-08	Meter Replacement/Enhancement Program (assumes full system upgrade to AMI)
MISC-09	Install pressure monitors and connect all turnouts to SCADA System
MISC-10	Continued Implementation of the Backflow Prevention Program
MISC-11	Conduct further recycled water studies for continued development of this program
MISC-12	Construct metered connections and replace valves at interties with East Palo Alto
MISC-13	Development of a Lead Service Replacement Program
MISC-14	Development of an Asset Management Program



- Proposed Pump Station
- Proposed Tank
- Proposed Check Valve
- Proposed Interconnection
- Proposed Emergency Well
- Existing Emergency Well
- Existing Pressure Reducing Valve Station
- SFPUC Turnout
- Proposed 8-inch Pipeline
- Proposed 10-inch Pipeline
- Proposed 12-inch Pipeline
- Existing Pipeline
- Water Service Area

Notes:
1. Storage Tank and Booster Pump station location is unknown and additional siting evaluations are recommended to confirm size and location of proposed future storage. The location shown on this figure is only shown as a place holder.
2. For the purposes of the hydraulic evaluation, the new well location was assumed to be near the intersection of Willow Road and Coleman Avenue. For the analysis it was assumed a full 1,500 gpm of production capacity was achieved. However, the actual location is unknown; and groundwater well siting analyses and testing are required to determine the future locations and production capacity.
3. Refer to Table ES-4 for project descriptions and associated costs.

CITY OF MENLO PARK — WEST YOST ASSOCIATES

Figure 9-1A

Recommended Improvements for the Lower and High Pressure Zones

Menlo Park Municipal Water
Water System Master Plan

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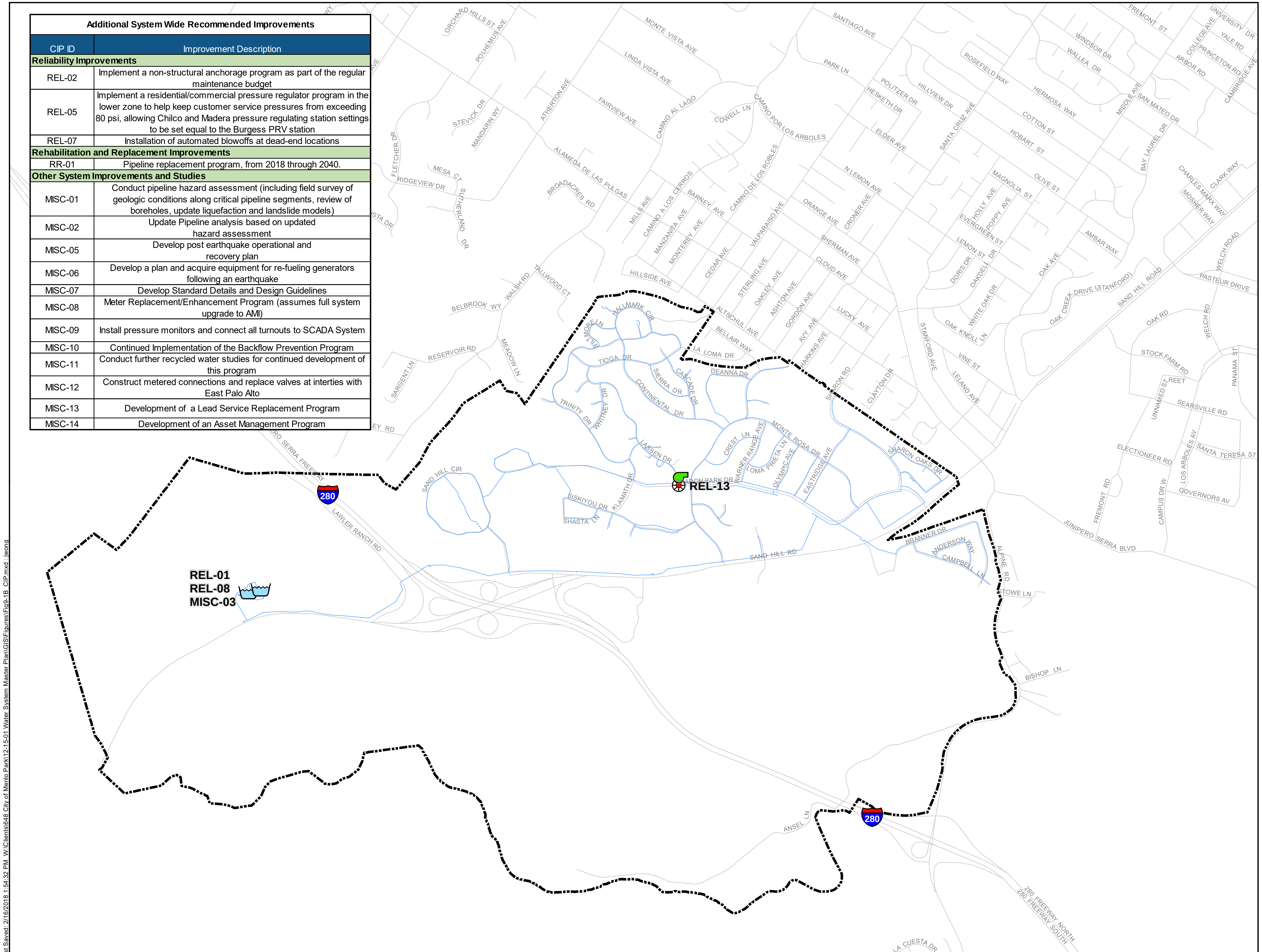
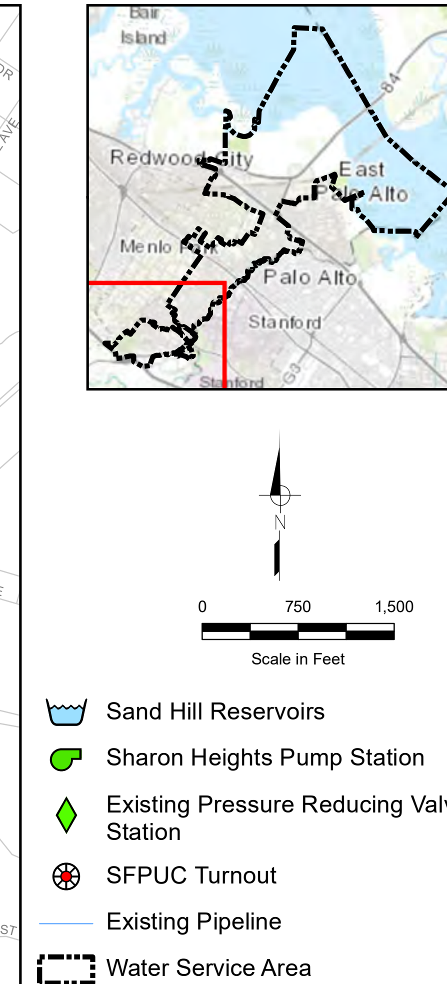
Additional System Wide Recommended Improvements

CIP ID	Improvement Description
Reliability Improvements	
REL-02	Implement a non-structural anchorage program as part of the regular maintenance budget
REL-05	Implement a residential/commercial pressure regulator program in the lower zone to help keep customer service pressures from exceeding 80 psi, allowing Chilco and Madera pressure regulating station settings to be set equal to the Burgess PRV station
REL-07	Installation of automated blowoffs at dead-end locations
Rehabilitation and Replacement Improvements	
RR-01	Pipeline replacement program, from 2018 through 2040.
Other System Improvements and Studies	
MISC-01	Conduct pipeline hazard assessment (including field survey of geologic conditions along critical pipeline segments, review of boreholes, update liquefaction and landslide models)
MISC-02	Update Pipeline analysis based on updated hazard assessment
MISC-05	Develop post earthquake operational and recovery plan
MISC-06	Develop a plan and acquire equipment for re-fueling generators following an earthquake
MISC-07	Develop Standard Details and Design Guidelines
MISC-08	Meter Replacement/Enhancement Program (assumes full system upgrade to AMI)
MISC-09	Install pressure monitors and connect all turnouts to SCADA System
MISC-10	Continued Implementation of the Backflow Prevention Program
MISC-11	Conduct further recycled water studies for continued development of this program
MISC-12	Construct metered connections and replace valves at interties with East Palo Alto
MISC-13	Development of a Lead Service Replacement Program
MISC-14	Development of an Asset Management Program





Notes:
1. Refer to Table ES-4 for project descriptions and associated costs.

CITY OF MENLO PARK

WEST YOST ASSOCIATES

Figure 9-1B
Recommended Improvements for the Upper Pressure Zone

Menlo Park Municipal Water
Water System Master Plan

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CHAPTER 10
Operations and Maintenance Evaluation

This chapter describes West Yost's review of the current O&M duties that are being performed by MPMW's water system O&M staff. West Yost reviewed several reference documents related to water department maintenance and operations activities, interviewed O&M staff, and toured visible water infrastructure facilities to gather the information needed to assess current O&M protocols. Several recommendations have been identified based on our O&M review and assessment. West Yost was also tasked with assessing the adequacy of the current O&M staffing levels. The staffing level assessment and recommendations are based on the current duties of current staff, a comparison with similar size water utilities, and based on the ability of staff to perform additional tasks recommended for the O&M program. This O&M review was completed in early 2016.

This chapter includes the following:

- A summary of the O&M reviews and findings.
- An assessment of the ability of the current O&M staff to perform current and recommended assignments and recommendations for possible staff augmentation. Staffing recommendations are compared with staffing levels at similar size utilities.
- A review and assessment of current maintenance procedures for several infrastructure types and recommended modifications and/or additions to those procedures to meet best practices and/or recommended regulatory guidelines.
- A review and assessment of the operational tasks, such as water quality, emergency planning, energy, and water efficiency, with recommendations for optimization of these tasks.

10.1 SUMMARY OF FINDINGS

West Yost performed a staffing assessment by reviewing current positions and duties of staff, and comparing staffing levels with similar sized municipal utilities. Current O&M staff levels do not allow for recommended preventative maintenance or operational optimization tasks to be performed. MPMW O&M staffing levels are insufficient when compared to the O&M staffing levels of similar size utilities. Current MPMW O&M certified operations staff are at risk of becoming burned out due to the combination of day-to-day duties and on-call requirements.

West Yost performed a maintenance review to assess current maintenance procedures for different water system assets. MPMW O&M staff are currently performing day-to-day corrective maintenance, and some preventative maintenance tasks. There are many preventative maintenance tasks that are not occurring at the frequency that is recommended by industry best practices, such as valve exercising, hydrant inspection and testing, pressure reducing valve (PRV) maintenance, and reservoir maintenance. Maintenance work orders are currently tracked using excel spreadsheets as there is no formal computerized maintenance and management system. Maintenance documentation is becoming backlogged due to time-constraints and lack of clerical support for field operations staff.

West Yost reviewed operational practices related to monitoring, water quality, water efficiency and emergency planning. Operations are being monitored through physical inspections and remotely through supervisory control and data acquisition (SCADA) telemetry. Water quality is good and sampling is being performed in compliance with regulatory requirements. Water system losses are being tracked and a meter replacement program has begun to address unaccounted for water loss. The MPMW ERP is out of date and necessary exercises associated with emergency planning are not occurring.

West Yost recommends seven full-time staff based on results of several staffing assessment analyses which include current O&M duties, recommended preventative maintenance and operational optimization tasks, and the results of a comparison with similar size utilities. Table 10-1 provides a summary of the findings, conclusions of various assessments, and overall recommendations associated with each of the reviews and assessments.

Based on the results of this staffing assessment, the City Council approved two positions as part of the budget process for fiscal year 2017-18. The staff report is included as Appendix G.

10.2 MAINTENANCE REVIEW

MPMW does not have an O&M manual or Standard Operating Procedures (SOP's) that describe the maintenance procedures currently being conducted by the staff. West Yost has prepared an O&M manual for MPMW as part of the scope of this WSMP project. Therefore, current maintenance activities are based on information obtained by interviewing Carlos Castro, the Water System Supervisor, and reviewing maintenance logs prepared by the Water System Supervisor that date back to November 2014. The Water System Supervisor has tried to develop SOP's but has not been able to make any progress due to lack of staffing. At the time of this evaluation, a preventative maintenance program was currently being developed. The maintenance review includes the assessment of current maintenance procedures for several infrastructure types and aspects which include the following:

- Condition assessment of pipes, valves, meters, and hydrants;
- Hydrant repair, replacement and testing;
- PRVs maintenance;
- Valve maintenance;
- Booster pump station maintenance (pumps and generators);
- Reservoir maintenance;
- System flushing; and
- Standardization of parts and materials.

Table 10-1. Summary of Key Systems Operations and Maintenance Findings and Recommendations

Category	Recommendation
Maintenance Review Summary • Prepare SOP's to provide step by step instructions to help workers carry out routine operations activities • No formal condition assessments have been conducted on system pipes, valves, meters, or hydrants • Maintenance work order logs are being prepared in excel spreadsheets and date back to 2014 • O&M staff have replaced and repaired many fire hydrants over the past two years • O&M staff are inspecting and testing fire hydrants, but not all hydrants are being inspected and/or tested annually • PRV's are inspected daily and the Burgess and Madera PRV's are tested biannually • Valving configurations at the PRV stations do not allow for easy repair and the stations would be difficult to take out of service • Connecting pipelines to the Burgess PRV are located under existing buildings • Valves are being exercised at a frequency of once every four years • Air release valve locations are unknown and maintenance is not being performed on these valves • The booster pump station is inspected daily and monitored via SCADA • The reservoirs are currently visually inspected daily. Water quality sampling at the reservoirs is conducted on a weekly basis. • The reservoirs do not have mixers installed to provide consistent water quality. A written protocol is in place for improving water quality in the reservoirs. • An interior reservoir inspection by divers was scheduled for January 2016 to evaluate the interior of the tanks • Dead-end mains are being flushed and monitored weekly for water quality • MPMW is currently in the process of updating its standard drawings	
Condition Assessment of Pipes, Valves, Meters, and Hydrants	• Include additional details in maintenance logs regarding conditions for future reference and input in to GIS database • Start condition assessment on infrastructure based on age and size
Hydrant Repair, Replacement, and Testing	• Implement routine inspection and maintenance from for hydrants • Perform biennial or triennial hydrant testing • Continue to keep records on fire hydrant maintenance, inspections, and testing • Prepare written guideline for hydrant inspection and testing procedures
PRV Maintenance	• Test PRV's annually, and rebuild and paint every 5 years • Test Madera PRV and rebuild, test Chilco PRV annually • Relocate Burgess PRV to eliminate piping that runs under existing structures • Without pressure regulation on the customer side, MPMW has little flexibility and has to rely on the Burgess PRV to serve most of the Lower Zone
Valve Maintenance	• Exercise Valves (12-inch and larger) every one to three years • Exercise valves (smaller than 12-inch) every four years • Locate ARV's and inspected annually • Document valve exercising info
Booster Pump Station Maintenance	• Perform daily inspections • Follow O&M and manufacturers recommendation for Pump Station maintenance • Test and service generator on a monthly basis • Measure pump capacity and efficiency with pump tests • Monitor for heat, vibration, and noise long-term • Document maintenance for reference and equipment warranty conditions • Prepare a site specific O & M Manual for the reconstructed Sharon Heights Booster Pump Station and keep it onsite as a reference for required maintenance activities
Reservoir Maintenance	• Perform daily inspections • Inspect reservoir interior every three to five years. • Clean reservoir on an annual or bi-annual basis • Recoat interior and roof of reservoir on a five to seven frequency or as needed • Inspect roof after storm events for ponding • Maintain and monitor vegetation around reservoirs • Prepare written operations manual for reservoir draining and filling, reservoir isolation, and disinfection
System Flushing	• Flush all dead end mains annually or as required to maintain water quality
Standardization of Parts and Materials	• Update standard drawings and create standard specifications • Prepare design guidelines • Involve O&M staff and preferences in standards and specifications updates • Involve O&M staff in plan reviews • Involve O&M staff in materials submittal reviews and construction inspections • Expose O&M staff to new information and technologies through participation in local, state, and national organizations

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Table 10-1. Summary of Key Systems Operations and Maintenance Findings and Recommendations

Category	Recommendation
Operations Optimization Review Summary • O&M staff visually inspect and use SCADA telemetry to remotely monitor critical system components • Water quality is good and sampling meets regulatory compliance requirements • An on-call operator is assigned during non-work hours to monitor the system and respond to emergency situations • A Computerized Maintenance and Management System (CMMS) is being developed. • Lost and unaccounted for water is being tracked and recorded • Customer meters are being replaced and repaired and remote reading capability is being added to these meters • A meter replacement program is recommended to replace all customer meters after they have reached a certain age Implementation of an AMR or Automated Meter Infrastructure program is being evaluated • Staff keeps records of unplanned discharges • MPMW has a Water System Emergency Response Plan that was prepared in 2009 • MPMW is a member of the California Water/Wastewater Agency Response Network	
General	• Establish Level of Service standards and goals for system performance, energy and water efficiency, and customer service and regularly evaluate performance against them • Maintain accurate system maps and records
Water Quality	• Prepare for revised TCR by documenting data on positive samples • Update sampling plan periodically based on changes that occur to the number of customers • Regularly review changes to sampling requirements through AWWA regulatory updates • Continue current sampling program
Monitoring	• Record and store SCADA data for future reference • Update SCADA to allow multiple users to monitor at the same time • Include preventative maintenance items and manufacturers recommended maintenance items in new CMMS program • Set reachable KPI targets for CMMS and evaluate them monthly
Energy Efficiency	• Record and analyze power charges for BPS • Evaluate operations and possible power savings based on time of use rates • Adding mixing within the reservoirs would change the operating requirements and open up opportunities for long-term energy savings
Water Efficiency	• Regularly calibrate large meters and SFPUC meters • Continue tracking lost and unaccounted for water with goal of achieving less than 10%. • Inaccuracies in existing production and consumption water meters makes assessing water loss difficult • Continue meter and service replacements and track effects on water loss • Continue keeping records of meter replacements and include data in GIS database • Continue implementation of AMR to reduce manual meter re-reads • Determine cost benefit for a leak detection program • Continue keeping records for unplanned discharges and include in GIS database
Emergency Planning	• Update and review Emergency Response Plan annually • Update Vulnerability Assessment, if needed • Conduct annual training tabletop exercises and communications drills • Conduct annual emergency exercises • Coordinate exercises with other local and regional agencies • Review and implement Seismic Vulnerability Assessment improvement program
Staffing Level Assessment Summary	• Existing staff are doing well in keeping up with day to day duties and corrective maintenance tasks • There is a shortage of staff to complete recommended preventative maintenance tasks and document maintenance activities • Work Orders associated with manual meter re-reads, final meter readings, and meter turn-offs represent a drain on operations staff resources • Backlog in documentation is occurring due to lack of office support • Existing staff run the risk of becoming burned-out based on current on-call requirements and lack of back-up staff • Current temporary employees are restricted in their hours and are not certified operators • Comparison to similar size utilities indicates that existing staffing is lacking in full time operator positions
Existing O&M Staff Assessment	• Several maintenance tasks are not being performed or are not being performed based on prudent industry practices due to a lack of sufficient staffing resources • Hire a minimum of six qualified operators to alternate on-call duties so each operator doesn't have to be available more than one week every six weeks • Hire office employee to complete administrative type duties like documentation, inventory management, purchasing, and reporting
Comparison to Similar Size Utilities	• Similar size utilities have an average O&M staffing level of seven full-time field employees not including administrative support.
Staffing Assessment Recommendations	• Provide staffing level of a minimum of six certified operators and one administrative person specifically assigned to provide office assistance for documentation, inventory management, purchasing, and reporting. • Hire operators with both treatment and distribution operator certifications to be able to provide additional help with future well sampling and fill-in for the existing Water Quality Specialist • Hire operator with experience in groundwater well water quality sampling and operations and maintenance. • Additional staffing beyond the recommended seven full-time employees may be needed for anticipated future tasks associated with a proposed new emergency well and implementation of a recycled water program.

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Recommended modifications and/or additions to the current procedures are made to meet best practices and/or recommended regulatory guidelines. In addition, West Yost recommends that MPMW prepare SOP's to provide step by step instructions to help workers carry out routine operations activities. SOP's are important to ensure efficiency, quality output and uniformity of performance and reduce miscommunication. SOP's are a valuable asset to guide new operators in performing day-to-day duties. Detailed assessments and recommendations are given below for each infrastructure type or aspect.

10.2.1 Condition Assessment of Pipelines, Valves, Meters, and Hydrants

Staff indicated that there have been no formal condition assessments conducted for system pipelines, valves, meters, or hydrants. Field staff have observed the current condition of many of the systems' accessible meters and hydrants during routine maintenance and/or testing. Current maintenance work order logs are being prepared in a spreadsheet by the Water System Supervisor and date back to 2014 when his employment with MPMW began. The current work order log details the location and date where a service, repair or replacement occurred, but does not detail the root cause, observed condition when exposed for repair or replacement, or the type of fix that was implemented to make the repair. This information will be important to know to determine current pipe condition and provide supporting information for asset management programs. Unfortunately, previous system operations staff did not keep detailed records of past system maintenance tasks that could be used as a historical record. Therefore, West Yost recommends the maintenance logs be updated to include the following information:

- Root cause of pipe leaks or ruptures
- Observed pipeline and valve conditions when exposed for repair or replacement, including photos
- Observed fire hydrant and flow meter conditions when maintained or tested, including photos
- Type of fix implemented for repairs, including photos of repair while exposed
- Details of replacements
    - — Type and quantity of materials used
    - — Make, model, serial number
    - — Detailed information on connection(s) to existing system
- Location of valves closed to conduct repair or replacement
- Service Zone
- GIS indicator/Facility ID
- Condition of pipeline when hot taps are performed, with a picture of pipeline sample from hot tap

This type of information can be uploaded to the GIS database for future reference. In addition, this information can be used to determine where clusters of repairs or replacements are occurring to determine if more comprehensive condition assessments are warranted. This information will also be useful for achieving the MPMW's standardization goals for parts and materials and ensuring that proper inventory is kept for emergency repairs.

To begin an assessment of the water system pipelines, valves, meters, and hydrants, an inventory of these items and their specifics must be made. An inventory has been completed as part of the WSMP. Important specifics that should be initially considered are size and age. The larger the pipeline, valve, or meter, the more critical is it to the distribution of water through the system. Water infrastructure condition deteriorates with age. For example, it is likely that the oldest pipelines and valves may be in the worst condition since they are nearing or have exceeded their useful life. West Yost recommends the largest and oldest pipelines, valves, and meters be assessed for condition first. Age and size are just a few of the factors that should be considered when determining a method of approach to condition assessments. Other factors include past maintenance records, as described above, materials of construction, soil conditions, and system pressure conditions.

10.2.2 Hydrant Repair, Replacement, and Testing

The MPMW system includes approximately 375 hydrants. Work order log records indicate the O&M staff have replaced and repaired many fire hydrants over the past two years. In 2014, there were 20 work orders that were related to hydrants that did not include flushing or fire flow testing. It is unclear from the lack of description in the work order log the specific task(s) that were performed on these hydrants. In 2015, the work order log format was revised to add additional detail on the specific task performed on the hydrant. As of August 2015, two new hydrants were installed, with one of the two indicated as a replacement, and one existing hydrant was repaired. Hydrant testing information is currently being recorded by staff and indicates that in 2014, 153 hydrant inspections were performed and 36 of those involved fire flow testing. As of July 2015, the log indicates 42 hydrant inspections were performed and 26 of those involved fire flow tests. There were several hydrants that were inspected on an annual basis. The current inspection and testing records indicate that not all hydrants are being inspected and/or tested annually.

The AWWA Manual M17 establishes recommendations for hydrant maintenance. To ensure a hydrant is in proper working condition when needed, a routine inspection and maintenance program should be implemented and followed. A hydrant inspection program has been implemented by staff and a log of inspection activities has been prepared. The inspection log contains the following information:

- Location address and notes
- Service zone
- Map book page and hydrant number
- Hydrant type, wet barrel or dry barrel

- Existence of blue hydrant street marker
- Hydrant information: number of turns, street or back of curb location
- Hydrant brand
- Date tested
- Static pressure
- Flow data: residual pressure, pilot pressure, flow from pilot, total gallons flowed
- Residual hydrant data: street address, static and residual pressure
- Discharge flow receiving water information: Cl2T (mg/L), NTU, pH, receiving water
- Location of gate valve for the fire hydrant and size

According to AWWA M17, hydrants should be inspected and exercised annually. A record should be kept on the performance of routine maintenance, observations during inspection, static pressure and flow measurements, and recommended actions. O&M staff should have spare parts on hand to perform simple repairs. Local fire code and fire authority guidelines should be followed during inspection and testing activities. In addition, a written guideline could be prepared for maintenance crews on the items to be inspected, testing inspection procedures, fire authority and customer outage notification procedures, and instructions for simple repairs.

Routine inspections of common fire hydrants by experienced operators should take approximately 20 minutes per hydrant, not including travel time and documentation. For the approximately 375 fire hydrants in the system, annual inspections of each hydrant, at a minimum, would require approximately 125 staff hours at 20 minutes a hydrant. Flow testing of each hydrant annually would take a significant amount of time and would discharge a large amount of potable water. Therefore, biennial or triennial flow testing may be a more achievable goal. This would require approximately 125 to 190 hydrants each year to be tested. Assuming travel, set-up, and documentation, each fire flow test could take several hours. At 1 to 1-1/2 hours per test, it is expected the total staff hours involved to test each hydrant would be in the range of 375 hours to 564 hours.

O&M staff indicate that existing system hydrants are the dry barrel type and are being replaced with wet barrel type hydrants. The dry barrel type hydrant is typically used in climates that experience freezing temperatures and hydrant flow is controlled by a valve at the base of the hydrant. A wet barrel hydrant has water in the barrel of the hydrant and is controlled by independent valves on the hydrant ports. Since Menlo Park does not typically experience freezing temperatures, the switch to wet barrel hydrants makes sense. Engineering staff have updated the standard drawings and specifications to reflect this change in hydrant type. O&M staff indicate that the estimated parts cost to retrofit an existing dry barrel hydrant is $3,500 and the cost of a complete replacement is in the range of $15,000 to $25,000 depending on project variables.

10.2.3 PRV Maintenance

Water is delivered to the MPMW system via five service connections (turnouts) from the SFPUC RWS. Three of the service connections have PRV stations (Burgess, Madera and Chilco), which reduce the pressure from the SFPUC RWS into the MPMW system. The critical nature of proactively maintaining system PRVs cannot be overemphasized due to the catastrophic consequences of possible failure. These consequences can include widespread infrastructure and property damage caused by a rapid increase in system pressure above the current pressure ratings of pipes and service lines. These PRVs reduce the elevated pressure received from the SFPUC turnouts (approximately 100 to140 psi) to a normal water distribution system pressure range (approximately 40 to 65 psi).

Staff indicate that the PRVs are inspected weekly and the Burgess and Madera PRVs are tested biennially to ensure proper operation. The Burgess PRV is the primary system that serves the Lower Zone, and was rebuilt in 2014. The Madera and Chilco PRVs are both backup PRVs to the Burgess unit. The Madera PRV was originally installed in 1983 and there are no records of the valves being rebuilt. The Chilco PRV is typically not used and was rebuilt in 2013 because the unit failed. The Chilco system has not been tested since 2013 due to its confined space designation and OSHA requirements for access. The PRV stations are not equipped with flow meters since they are located directly downstream of the SFPUC turnouts which have their own flow meters. Daily inspections include visual inspection and recording system pressures.

PRV maintenance is dependent on periodic testing with internal inspection, the results of which will indicate if immediate repair is required. Detailed inspections and testing are best to be completed by the PRV manufacturer and their qualified technicians because they are most familiar with the internal workings of their product. The technician should disassemble the valve, clean it, and examine the PRV parts. Part of the examination is to compare the component dimensions with original acceptance specifications and criteria. In addition, the technician will review the PRV spring, to make sure it is within the correct operating range and make any necessary adjustments. In many cases, inspections and testing will result in the need to re-build a PRV or possibly replace it with a new PRV.

West Yost recommends all PRVs be tested annually and be rebuilt and painted every five years, or as necessary. The recommended testing routine is currently being implemented for the Burgess PRV. The Madera PRV needs be tested and rebuilt, if necessary, to ensure functionality when needed. The Chilco PRV should be tested annually and was recently rebuilt in 2013.

Operations staff indicate that the current valving configurations at the PRV stations do not allow for easy piping and appurtenance repair and the stations would be difficult to take out of service due to high pressure issues.

The Burgess PRV station is located in Burgess Park, near the parking lot between the City Administration building and the Arrillaga Family Gymnastics Center. The Water System Supervisor indicated that it would be desirable for the Lower Zone to be less dependent on the Burgess PRV station. The Chilco PRV and/or the Madera PRV would need to be utilized more to achieve less dependence on the Burgess PRV. The Water System Supervisor has been hesitant to use these PRVs more due to the access issues and lack of preventative maintenance related to these

PRVs. In addition, the properties in the Lower Zone receive water that is regulated in pressure. As a result, properties are not required to have individual water pressure regulators. An increase in pressure at the Madera or Chilco PRVs would be required for those turnouts to serve a larger section of the Lower Zone. Due to the fact that properties do not have pressure regulators, higher system operating pressures would likely impact the delivery of water to customers. Without pressure regulation on the customer side, MPMW has little flexibility and has to rely on the Burgess PRV to serve most of the Lower Zone. MPMW might consider implementing a water pressure regulator program for private property owners.[1]

In addition, a new or rerouted SFPUC interconnection and new PRV station would be recommended for the Burgess PRV.[2] The reason for this recommendation is due to existing structures (SRI building and Skate Park) being located on top of existing pipelines that connect to the Burgess PRV station. All pipelines should be accessible for maintenance purposes, especially pipelines that have high pressures. Possible locations for the new turnout would be along Burgess Drive with the PRV relocated near or at the adjacent MPMW maintenance yard.

10.2.4 Valve Maintenance

According to the current field data collection program, the MPMW system has approximately 1,165 valves, not including hydrant shutoff valves. The 2014 Annual Report to the Drinking Water Program reported that approximately 200 valves were exercised in 2014. The anticipated frequency of exercising was reported as every two to three years.

AWWA recommends all water utilities initiate a valve exercising program that requires all valves (including air valves and blow-offs) be inspected and operated on a regular basis. The key benefits of this program include the following: improve valve and distribution system reliability, reduce water loss, identify critical valves in the distribution system, document valve operation, identify and repair non-functional valves, ensure system isolation capability and control water quality.

AWWA Manual M44 establishes recommendations for valve exercising programs. Valve exercising programs should be based on age, hydraulics, and unique system conditions. Typical utilities exercise their larger (12-inch diameter and larger) valves and critical system valves every one to three years and smaller valves (smaller than 12-inch diameter) every four to five years. West Yost recommends MPMW set a goal to exercise their larger and more critical valves every two years and their smaller valves every four years. Of the total number of valves, it is estimated that 164 valves are 12-inch in diameter or larger based on the current field data collection program. The estimated number of staff hours to exercise the larger valves biennially is 82 hours assuming 1 hour per valve for travel, location, and documentation. The annual small valve exercising would be broken into four years at a rate of 250 valves per year. The estimated number of staff hours to exercise the small valves annually is 250 hours assuming 1 hour per valve for travel, location, and

[1] This program has been included in the recommended capital improvement program developed for this WSMP.
[2] The renewal and replacement program indicates that pipelines under the Skate Park and on the SRI property should be re-located to public rights-of-way. The PRV station is located on City-owned property.

documentation. The total staff hours per year anticipated for valve exercising would be 332 hours for both small and large-diameter valves.

Based on the 2014 Annual Report to the Drinking Water Program, valves are being exercised approximately once every four years. However, there are no documentation records regarding which valves were exercised and how often. The valves exercised are mostly those that have been accessed during water main breaks. Therefore, West Yost recommends documentation on valve exercising be kept for future reference. At a minimum, documentation should include the following: valve GIS ID number, location, size, number of turns, and the date exercised.

Air release valves (ARVs) have not been exercised or inspected because valve locations are not known. AWWA Manual M51 establishes recommendations for ARV O&M. ARVs are also important to keep in functioning condition. Build-up of air in pipelines can cause flow to be severely restricted through higher head loss and air binding. ARVs are also important to allow air into the system when pipes are drained, for surge control, and to avoid air vacuum and pipe collapse. ARVs should be protected from contamination and flooding. ARVs are recommended to be inspected annually.

10.2.5 Booster Pump Station Maintenance

The MPMW distribution system includes one booster pump station, the Sharon Heights Booster Pump Station, which was recently reconstructed. An O&M Manual for the facility was not prepared after construction was completed. It is recommended that MPMW prepare a site-specific O & M Manual and keep it onsite as a reference for required maintenance activities. The pump station site has the most expensive and maintenance intensive mechanical and electrical equipment within the water system and ensuring the site is maintained properly should be a high priority. Currently, the Water System Supervisor visits the pump station on a daily basis to inspect equipment and station operations. The station can also be monitored remotely via the telemetry/SCADA system. All water department staff have access to the telemetry/SCADA system. An on-site standby generator is activated by an automatic transfer switch in the case of a loss of power.

West Yost recommends the generator be tested and serviced on a monthly basis to ensure automatic operational functionality. Testing frequency should also comply with air quality permit requirements. In addition, the generator fuel level should be observed and maintained based on use. All pump station equipment should be maintained according to manufacturer’s recommendations. West Yost recommends all equipment maintenance be documented for historical reference and warranty conditions. Documentation should include records of the following:

- Oil levels, lubrication
- Suction and discharge pressures
- Pump motor run hours
- Number of pump stops and starts
- Station flow

- Power usage and cost
- Testing results
- Motor current draw

West Yost recommends that daily inspections of this facility continue and that O&M Manual and manufacturers recommendations be followed for maintenance activities.

In the long-term, West Yost recommends that pump capacity and efficiency be measured with pump tests. The pump tests should be compared to the original factory settings to determine the pump health index. The pump health index is a method used to track pump health. The pump health index can be used to determine when pumps should be targeted for repair and/or replacement due to wear. West Yost recommends pumps be periodically monitored for heat, vibration, and noise. Pumps and motors should be tested for heat and vibration through thermography and vibration analysis. These tests are used to identify pump issues that may reduce the overall life of a pump. Thermal imaging can identify issues with grease and oil or worn pump bearings. Vibration testing can identify issues with bearings and/or shaft and motor alignment. Motor resistance testing can also identify motor winding insulation health. These types of tests are considered preventative maintenance items to extend the life and efficiency of pumping equipment.

10.2.6 Reservoir Maintenance

The MWMW distribution system includes two water storage reservoirs, a 2.0 MG reservoir and a 3.5 MG reservoir, that service the Sharon Heights zone. Water storage reservoirs need to be periodically inspected and cleaned to help maintain good water quality in the distribution system, and to help extend the life of the reservoir. Regular inspections can also identify small problems that may develop into major problems that can create health related issues, lead to costly repairs or premature tank failure. Reservoirs that are not periodically cleaned can cause contamination events that may harm human health or contribute to customer complaints.

Reservoirs are currently inspected weekly. Water quality sampling at the reservoirs is conducted on a monthly basis with samples taken for the following constituents: chlorine, pH, monochloramine, free ammonia, nitrate and nitrite (indicators of nitrification), conductivity, turbidity, TDS, and temperature. The reservoirs currently do not have mixers installed to provide consistent water quality. Therefore, water quality results are analyzed to determine chorine residual and to assure water turnover occurs within the reservoirs. The MPMW has a written protocol in place for improving water quality in the reservoirs. The protocol includes several operational methods to improve mixing and water cycling within the reservoirs.

Reservoir levels are monitored by the SCADA system and adjusted by adjusting pump start and stop settings at the Sharon Heights booster pump station. An interior inspection by divers was done for Reservoir No. 1 in January 2016 to evaluate the interior of the tank.

Reservoirs will need to be drained for maintenance, cleaning, and/or repairs. Cleaning recommendations includes the removal of fine sediment that can build up on the reservoir floor or removal of oil that floats on the water surface. After a reservoir is drained, it must be disinfected according to AWWA C652, Disinfection of Water Storage Facilities, before being returned to service. An alternative to draining a reservoir is using divers or remote operated vehicles. In addition, West Yost recommends level probes be cleaned and maintained according to manufacturer's recommendations. Development of a written operations manual is recommended to detail the procedure for draining and filling the tank(s), isolating each tank, and tank disinfection procedures for reference.

Weekly inspection of the reservoirs is currently being conducted by staff. West Yost recommends that inspections be conducted on a daily basis. Daily inspections are recommended because this is the only water storage site within the system and there are no security features at the site that can be monitored between weekly inspections. For example, there are no cameras or intrusion alarms located at the site or on the reservoir access points and therefore there is no way for operations staff to know if the site has been penetrated or if the reservoirs have been contaminated, without routine inspections. If weekly inspections remain in place and an intrusion does occur, it could be up to a week before it is identified. Daily inspection recommendations include monitoring for security breaches and equipment operation and condition. Interior reservoir inspection is recommended every three to five years or more regularly based on condition and age. Repairs should be made to correct deficiencies as they are identified through inspections. Reservoir cleaning is recommended on an annual or biennial basis and the interior and exterior roof is recommended for recoating as needed or on a five to seven-year frequency at a minimum. Reservoir roof structure inspection is recommended during or directly after storm events to inspect for rainwater ponding which can lead to leaks. Vegetation and trees around the tank should be continually maintained. West Yost recommends trees with root systems that could compromise the underground reservoirs be removed.

10.2.7 System Flushing

Dead-end water mains require flushing to remove sediment buildup and improve water quality to customers with meters located off of these mains. Water quality in dead-end mains can suffer due to water age and the lack of circulation that occurs in a dead-end pipe. Water quality parameters that are sampled to determine if flushing is needed are typically turbidity and chlorine residual.

According to the 2014 Annual Report, there are 61 dead-end mains in the system. Only 46 of the 61 dead-end mains are equipped with blow-offs that facilitate efficient flushing. In 2014, all 61 dead-end mains were flushed by O&M staff. In 2014, these mains were monitored weekly for water quality and flushed as-needed. Staff have not been flushing dead-end mains recently due to drought conditions and customer perception of water wasting. West Yost recommends all dead-end mains be flushed annually or on a more frequent basis if required. Customer water quality complaints may require more frequent flushing. Other non-dead-end distribution mains require flushing only as necessary to remove built up sediment. Each time a main is flushed it should be documented. Flushing discharge water will need to be monitored for discharge permit reporting.

California Code of Regulations Title 22 Section 64575 sets requirements for flushing appurtenances and velocities. AWWA Standard G200 addresses basic principles of a flushing program. These references are recommended to be used to develop a written water main flushing program to establish a baseline.

Coordinating preventative maintenance activities, such as flushing, valve exercising, and hydrant testing would be the most efficient use of limited staff time.

10.2.8 Standardization of Parts and Materials

O&M staff play a critical role in the early design of infrastructure, especially when determining and establishing specifications and standards for design and construction. O&M staff have a unique knowledge of how the weaknesses in design and standards affect performance levels of infrastructure, which is gained through the O&M of the water distribution system. The importance of early input into the process of setting standards and specifications will identify problems that have been obvious to field personnel.

Standardization of part and material preferences prior to design should achieve a limited number of types of materials that will require to be stocked for replacement and/or repair. By limiting these preferences, on-hand inventory needed may be reduced, and the warehouse space needed to house that inventory is also reduced. Another benefit of reducing the overall parts and materials inventory is the cost savings that will be realized when keeping limited types of repair or replacement parts on hand.

MPMW is currently in the process of updating its standard drawings. Several of the current standard drawings were updated in 2012 and the hydrant detail was recently updated in December 2015. There are also some standard drawings which have not been updated in eight years or more. The current cathodic protection details were last updated in 1997 and may not reflect current technology. These details should be periodically reviewed by a licensed corrosion engineer. There may also be a benefit to adding additional standard details for the following:

- Temporary flush-out assembly
- Pipe cut-in based on pipe material
- Steel casing for jack and bore
- Service connections

The current standard drawings can be accessed from MPMW’s website. MPMW does not currently have a set of standard specifications. West Yost recommends standard specifications be prepared to insure the Districts preferred materials and construction methods are followed by contractors. It would also be beneficial to make MPMW’s standard specifications available via the website for easy access by contractors and design engineers. MPMW could also prepare design guidelines for water system infrastructure. Design guidelines will provide design engineers direction on main line sizing, valve type and arrangements, standard notes to include in design plans, easement requirements, and plan check fees and procedures.

Many utilities adopt and specify AWWA standards for infrastructure components. West Yost recommends operator preferences be incorporated into standard specifications and drawings as they will be expected to repair, replace, operate and maintain the infrastructure.

Standard specifications and drawings are a guide for engineers to design infrastructure. Once plans have been prepared they must be reviewed to confirm they conform to the standard specifications and drawings. Currently O&M staff are involved with review of design drawings. West Yost recommends that O&M staff continue to be involved in this review process as they can identify and correct potential problems before they are implemented through construction. Implementing standards is not complete after a design is approved. West Yost recommends O&M staff be involved in reviewing Contractor materials submittals and shop drawings to ensure the specifications are being met. The final step in implementation is conducting construction inspections of contractor work to ensure that the correct parts and materials were used during construction and that work is in compliance with approved plans.

West Yost recommends O&M staff be exposed to new technology in parts and materials to know when changing specifications could provide benefits to O&M of the utility. This can be accomplished by having staff involved as active members in local, state, and national organizations that focus on improving water utility operations, maintenance, and management through sharing information and technologies. While this area is often subject to budget scrutiny, it is a key investment that a utility can make in ensuring that its' staff are knowledgeable and are using or planning for state-of-the-industry improvements.

10.3 OPERATIONAL OPTIMIZATION REVIEW

Routine operations involve the analysis, formulation and implementation of procedures to ensure that the distribution facilities are functioning efficiently and meeting pressure and water quality requirements of the system. O&M staff currently visually inspect and use SCADA telemetry to remotely monitor critical system components. In addition, the O&M staff currently provide in-house routine maintenance, repair and replacement services for most infrastructure. Large pipeline repair and replacements are currently subcontracted out due to a lack of resources and equipment needed to make these types of repairs. Additional staff duties include maintaining accurate system maps and records and developing and testing MPMW's ERP.

Municipal utilities commonly use LOS standards to evaluate whether the physical systems and operations are functioning at an adequate level. LOS can be defined in terms of whether the utility complies with all regulatory standards for water quality and system design and operation. LOS standards define a specific goal or expectation, are quantifiable and measurable, and are constrained by available budgets for maintenance, repair and replacement. West Yost recommends LOS standards be defined for: system performance including service interruption due to breakage, pressure, and system reliability; sustainability (energy and water efficiency); and customer service (response to water quality and service related complaints).

Below are some simple examples of system performance, sustainability, and customer service LOS standards that could be used to evaluate operational optimization:

- System Performance. Service interruption due to line breaks. During a three-year period, no customer will experience more than three service interruptions due to a line break; such service interruptions will average four hours or less.
- Energy Efficiency. All new pumps rated 80 percent efficient or higher, unless additional capital cost for high efficiency pumps makes it not cost effective to purchase.
- Customer Service. The staff respond to main breaks within 30 minutes during work hours and within 1 hour during non-work hours, with a goal of no or minimal customer complaints about loss of service.

West Yost recommends staff establish LOS standards and evaluate, on a regular basis, the on-going performance of staff's ability to achieve the established standards.

West Yost has performed evaluations of the staff performance for water quality, monitoring, energy and water efficiency, and emergency planning aspects.

10.3.1 Water Quality

Through interviews with MPMW staff and analysis of water quality data provided to West Yost, an assessment of distribution system water quality was performed with a focus on regulatory compliance and customer satisfaction. Overall the water quality in the MPMW's water system is high, due in part to excellent source water quality.

From an operations standpoint, system operating conditions, such as low water velocities, supply sources going on and offline, and the amount of time that systems store water, can greatly affect water quality. Any of these factors can cause chlorine residual to be depleted, and allow microbial growth in the network. Hydraulic conditions can cause sediment to deposit, accumulate, and serve as both habitat for microorganisms and protection of microorganisms from disinfectants that would prevent microbial growth. Long storage times and lack of water turnover in storage tanks can also degrade water quality.

MPMW operates a "consecutive system" (purchasing water rather than managing its own water sources and treatment facilities); therefore, water quality compliance primarily pertains to the quality of water in the distribution system. Under the federal Safe Drinking Water Act and California Code of Regulations Title 22, permitted public water systems must monitor their distribution systems for compliance with the chlorine residual requirements of the Surface Water Treatment Rule (SWTR), the Total Coliform Rule (rTCR), the Lead and Copper Rule, Stage 2 Disinfectant/Disinfection Byproducts Rule, and Fluoride regulations. Additional bacteriological monitoring and sampling is carried out after main repair, main installation, repair or maintenance on the reservoirs, and after any system pressure loss where system pressure drops to less than 5 psi.

The operational staff currently monitor for the following water quality constituents: total chlorine, turbidity, conductivity, TDS, pH, temperature, color, odor, chloramine, ammonia, and nitrate levels. These constituents are sampled weekly at six sample site locations throughout the distribution system. Sampling at the reservoir is made at separate sample port on each reservoir on a monthly basis.

MPMW uses the SFPUC laboratory to analyze its water samples for total coliform, E.coli and other physical chemistry characteristics. The SFPUC laboratory has been approved to perform those analyses by the California State Water Resources Control Board Division of Drinking Water and uses US Environmental Protection Agency (USEPA) approved standard methods as prescribed in the Code of Federal Regulations. The lab delivers reports to MPMW staff within 3 days of sample collection. Whenever the presence of total coliform, fecal coliforms or E.coli is found in a sample, the lab will contact MPMW staff within 24 hours or immediately by phone or email.

MPMW currently has a written protocol for improving water quality in the reservoirs. The protocol includes several operational methods to improve mixing and water cycling within the reservoirs.

MPMW has recently been given authorization to drill a new water supply well. The well will be used as an emergency standby supply for the water system. The new well will be required to be sampled for water quality initially before being put into service and on a regular basis for a large number of constituents. Additional well water treatment may be needed depending on the results of the initial sampling. On-going water quality sampling for the new standby well will be required per the current State Water Code to include: bacterial indicators; general minerals and ions; metals; organics; and radionuclides. The new well source water will also need to be chloraminated before entering the distribution system. This is a new operational task that is not currently being performed by staff. Additional water quality testing and chloramination O&M will increase the existing workload of the current Water Quality Specialist and may require a second operator with an equal or greater water treatment operator certification level. The current staff recommendations do not fully account for this additional staff effort and the amount of operator time dedicated to these tasks will not be fully understood until the well is drilled and its source water quality is analyzed. Regardless of whether the well is only used for emergency purposes, it must be operated and maintained to be ready to be brought online during an emergency, and water quality sampling and reporting must be conducted even if the well is not actively supplying the system.

The following sections describe the evaluations completed for the distribution system regulations listed above as they pertain to MPMW, and include West Yost's recommendations.

10.3.1.1 Chlorine Residual

The SWTR requires that chlorine residual be monitored within distribution systems at the same location and frequency as the rTCR sampling. Sampling plans are to include sampling locations that represent water quality within the system. A review of the list of sampling locations provided in the Sample Siting Plan, dated October 28, 2010, indicate MPMW has five water sample collection stations in its Upper Zone, four in its Lower Zone, and two in its High Pressure Zone. This sampling plan was revised and updated in February 2016 and now includes a total of 15 sampling locations. MPMW now has a total of six sample collection stations in its Upper Zone, seven in its Lower Zone and two in the High Pressure Zone. These changes were made in anticipation of future population growth within the MPMW's service area. In addition, the number of samples collected was increased from four to six. MPMW's Water Quality Specialist collects weekly samples from the sample collection stations according to instructions provided by the SFPUC lab. A minimum of six total coliform samples are to be collected each week, two from the Upper Zone and two from the Lower Zone.

Weekly water quality data from 2014 were reviewed to assess whether there were significant losses of chlorine in water as it travels through the system. Based on the review of these data, water quality monitoring results for the majority of the MPMW's water system were generally close in value to the entry point chlorine residual.

Chlorine residual should continue to be monitored at the total coliform sampling locations. Staff currently reports and should continue to report quarterly to the State Water Resources Control Board (SWRCB) regarding disinfection chlorine levels.

10.3.1.2 Total Coliform Bacteria and E. coli

In April 2016, the revised rTCR replaced the existing TCRr. The major difference between the two is that the rTCR will not have a maximum contaminant level (MCL) for total coliform bacteria. Instead, water utilities that exceed specified values will be required to perform an assessment to determine probable causes for the occurrence of coliform bacteria at the distribution system location (corresponding to repeated positive total coliform or E. coli sampling results). The presence of coliform bacteria in the distribution system could be a result of insufficient disinfection or filtration, sloughing off of biofilm on pipe walls, or a cross-connection in which microbial contaminants enter the system (usually upstream of the positive sample). The USEPA along with the AWWA are currently drafting guidance manuals for utilities in the event that they need to perform an assessment for compliance purposes.

Staff reports monthly to the SWRCB regarding system coliform monitoring. There are approximately 24 monthly samples taken and evaluated for total coliform positive and Fecal/E.coli positives. These samples are taken in both the Upper Zone and Lower Zone.

MPMW's Water Quality Specialist collects weekly samples from the sample collection stations according to instructions provided by the SFPUC lab. A minimum of six total coliform samples are to be collected each week. Repeat sampling is required if a sample result is positive. If repeat samples are positive, the staff must notify CDPH within 24 hours.

A review of the MPMW's monitoring results for the rTCR compliance monitoring indicate the system is in compliance with the rTCR. The sampling records reviewed specified chain of custody information along with the analyst name and data corresponding to analytical results.

In preparation for the rTCR, it is recommended the MPMW document where positive coliform samples have occurred in the past, and discuss whether reasons for such occurrences can be explained. Low chlorine residuals are not considered an adequate explanation under most circumstances, since low chlorine residual values often do not correspond with positive coliform sampling results. This exercise will prove beneficial in the event of a positive coliform occurrence after the implementation of the rTCR.

Sampling records are currently documented in a spreadsheet. West Yost recommends sampling records be kept for five years. In addition, the Sample Siting Plan is recommended for periodic updates, based on changes that occur to the number of customers served by the distribution system.

10.3.1.3 Lead and Copper Rule

Lead and Copper sampling was conducted in 2015. Continued compliance is expected based on SFPUC's current corrosion control practices and need to comply with this regulation in their own distribution system. Therefore, it is not anticipated that changes in water quality would cause water to become more corrosive, resulting in non-compliance with this regulation.

Samples are taken by staff and analyzed by McCampbell Analytical. McCampbell Analytical is California State certified by the Environmental Laboratory Accreditation Program, certification #1644. Annual samples are typically collected between June and September.

It is recommended MPMW continue its current lead and copper compliance plan and stay informed of any changes to the Lead and Copper Rule through AWWA's regulatory updates.

10.3.1.4 Stage 2 Disinfectant/Disinfection By-products Rule

The MPMW system receives SFPUC water which has been chloraminated. West Yost reviewed the MPWM 2015 Consumer Confidence Report which indicates compliance monitoring results for the Stage 2 Disinfectant/Disinfection By-products Rule. Our review indicates both the total trihalomethanes and haloacetic acid levels were well below the running annual average MCLs.

During the USEPA's regulatory negotiation for the Stage 2 Disinfectant/Disinfection By-products Rule, there was a fair amount of discussion regarding lowering the MCLs in the future. There was strong opposition among the water industry representatives for lowering of the MCLs based on the lack of health effects data needed to justify the high costs that would be required for technology changes nationwide to comply with significantly lower values.

It is recommended that MPMW continue its' current Disinfectant/Disinfection By-products Rule monitoring and reporting program.

10.3.1.5 Fluoride Regulation

California Assembly Bill (AB) 733 was signed in 1995 authorizing the SWRCB to require water systems serving over 10,000 people to fluoridate their system. In April 1998, the California Code of Regulations was amended to describe the regulatory requirements of fluoridation in public water systems (Title 22, Section s 64433 and 64434). Therefore, the fluoridation of water in California is a legislative matter as much as it is a regulatory matter. Sometimes customers express their views regarding fluoridation to water utilities. The appropriate place for such discussion is in the legislature, not the water utility which has no option but to comply with laws so as not to jeopardize its permit to operate. MPMW is listed on the SWRCB website as a system which receives fluoridated water from SFPUC.[3] According to the CDPH Drinking Water Program 2013 Annual Fluoridation Report, the average monthly fluoride concentration in the MPMW system was 0.76 with an optimum fluoride level of 1.00. The MPWMD 2015 Consumer Confidence Report indicates an average fluoride concentration of 0.3.

Beneficial health effects of fluoride have been known since the 1950s. Fluoride is an integral component of oral hygiene and health, important to the maintenance of overall health and avoidance of chronic diseases. Proper addition, control (including monitoring) of fluoride is considered advantageous to the health consumers of public water systems.

West Yost recommends MPMW continue its current fluoride monitoring and reporting program. Discussions with consumers should focus on the fact that in California the addition of fluoride is a legislative mandate beyond the control of public utilities (regardless of whether as public servants they are proponents or opponents of fluoridation).

[3] http://www.waterboards.ca.gov/drinking_water/certlic/drinkingwater/documents/fluoridation/Tables/Data2013.pdf

10.3.2 Monitoring

In addition to required sampling for water quality, monitoring of the distribution system involves reviewing booster station run times, storage tank levels and security measures. Operations are currently monitored remotely with a SCADA system. The SCADA system is a centralized computer network that remotely controls and monitors certain aspects of the distribution system based on current system instrumentation capabilities. Functions that the current SCADA system performs include: flow monitoring based on flow meter signals; tanks levels and pressures based on level switches and pressure transducers; pump operation including run hours, pump suction and discharge pressures, pump alarms, and number of pump starts and stops; back-up generator operation; and PRV operation. The SCADA system can also monitor intrusion alarms if they are present at facilities. West Yost recommends SCADA data be recorded and stored for future analysis and reference.

The current SCADA system was upgraded in early 2016 and is now installed in a virtualized environment. The system's architecture was revised to include redundant servers and a program to record all data trends.

The water system is monitored at all times during work hours. There is an on-call operator assigned during non-work hours to monitor the system and respond to emergency situations. Each certified operator is on call on a rotating basis. There are currently only three certified operators for the water system and thus this requires one operator to provide more than one on-call weekly shift each month. When an operator is required to be on-call they must be available and within a close vicinity to respond at any moment. This burden significantly restricts that person's ability to leave town or commit to other outside personal activities while on call. This can be a significant burden when an operator is required to complete two on-call shifts in a single month. This basically means for half the month the operator is restricted from leaving the area and cannot commit to outside personal activities in addition to their day-to-day job duties.

As part of the City's Information Technology Master Plan, a computerized maintenance management system (CMMS) will be evaluated. However, that study is in the evaluation phase. All MPMW records are currently kept as excel spreadsheets. The current spreadsheet documents the following data: date work order completed; the street address; the issue date of the work order and who issued it; work order and CIS numbers; the issue the work order addresses; who completed the work order; the date data was entered into the Fathom work order system; and any applicable notes. West Yost recommends the CMMS system include information needed to generate work orders for preventative maintenance items which includes recommendations from individual equipment O&M manuals.

The CMMS program should generate work orders and evaluate operational performance based on key performance indicators (KPI's). Typical KPI's may include the number of preventative vs. corrective work orders being generated, the number of outstanding work orders or the number, of hours spent on preventative vs. corrective work. West Yost recommends setting reachable targets for each KPI and evaluating KPI performance be evaluated based on the established targets.

10.3.3 Energy Efficiency

The only significant energy-using piece of equipment currently in the system is the Sharon Heights booster pump station. The pumps and motors were installed in 2015 and should be up to current efficiency standards. West Yost recommends power records for this facility be recorded and analyzed to identify changes in power use that indicate potential failures in pumping equipment or possible power meter misreads. It is also important to generate a power use baseline while the facility is still new to gauge how equipment efficiency may be degrading over time. This information may be used to determine when equipment should be replaced with more efficient equipment to realize energy savings.

It is recommended to evaluate if power charges are based on time of use. If time of use charges are being implemented, the operator could look at the possibility of changes to system operation to avoid incurring charges during the highest cost periods. In some cases, power charges may be higher during peak energy use times. An effective way to reduce power costs is to adjust operations by having pumping occur during off-peak times. Currently, reservoirs are operated to maintain water quality, which limits flexibility for off-peak pumping. The reservoirs can be equipped with mixing systems to reduce stratification and nitrification water quality issues that occur if the reservoir is not turned over frequently. Adding mixing within the reservoirs would change the operating requirements and open up opportunities for long-term energy savings.[4]

West Yost recommends the new well power costs also be monitored, documented, and evaluated in the same fashion as the booster pumps.

10.3.4 Water Efficiency

Water distribution system leaks and inaccurate meters can cost a utility a significant amount of money in unrealized revenue. Monitoring lost and unaccounted for water can provide a tool to assess water leakage and meter inaccuracy system wide. Water loss in 2013 and 2014 was approximately 14 percent and negative 1 percent, respectively. The 2014 water loss is questionable because the system can never consume more water than it produces and may point to inaccurate production metering. It is reported by staff that almost a quarter of the systems water meters are over 30 years old. Meters this old are assumed to have some level of inaccuracy. Inaccuracies in production and consumption water meters makes assessing water loss difficult, if not impossible. Staff indicated that meter replacements have begun in the Sharon Heights area where many meters can be rebuilt rather than replaced. Meter rebuilds are about a third the cost of replacement. Some meters cannot be rebuilt due to outdated or obsolete parts and require replacement. In addition, when a service line is identified to be replaced, the meter will also be replaced at the same time. Meter replacements records were not being kept prior to 2014. Meter replacements for 2-inch and smaller meters can be replaced using in-house operations staff. Staff indicate that it takes 2 to 3 operators a full day to replace 3 meters, depending on the size of the unit, the location, and the overall complexity of the work.

[4] MPMW has a program underway to install mixers at the reservoirs.

Meter replacements 3 inches and larger are being subcontracted out for replacement. When a meter is replaced, everything must be brought up to current code including the meter vaults for large meters. In-house staff do not have the resources or equipment necessary to replace the large vaults that house meters 3-inch and larger. Many large meters cannot be rebuilt because the meter is obsolete and a rebuild kit not available.

When meters are rebuilt or replaced, remote reading capabilities are incorporated into the metering system. Staff has been working with Sensus on implementation aspects of an AMR. Implementation of an AMR or AMI program are being evaluated as part of this WSMP. Currently, meters are initially read by an outside contractor who is responsible for billing. There are numerous work order requests generated by the outside contractor on a monthly basis to have meters manually re-read. Meter re-reads are completed by operations staff and accounted for 26 percent of the documented work orders generated in 2015. This task appears to be a drain on current staff resources. Implementation of an AMR or AMI system would significantly reduce the need for manual meter re-reads and thus free up operations staff time for other important maintenance tasks. West Yost recommends existing meters, especially large meters, be calibrated regularly to ensure accurate readings are occurring. Although AMR will reduce the level of effort associated with re-reads, meter boxes will still need to be maintained to ensure access.

A leak detection program can also be implemented in addition to meter replacement to reduce overall system water loss. A successful leak-detection program can also help to meet water conservation goals. Old and poorly constructed pipelines, inadequate corrosion protection, poorly maintained valves, and mechanical damage are some factors that contribute to water leakage. Undetected leaks can lead to the loss of large quantities of water depending on how long they have existed before being identified and repaired. It may be necessary to determine the cost and benefit of implementing a leak detection program. This would include starting by determining the estimated value of lost revenue based on the volume of water system losses that are occurring. The value of lost revenue can be compared to the cost of corrective measures to determine if a leak detection program is financially viable.

There are various methods of detecting water distribution system leaks, such as sonic leak detection equipment. Sonic leak detection equipment identifies the sound of water escaping a pipe. Leak detection systems should be focused on locations within the distribution system with the following characteristics: the greatest potential for leaks or in areas where there is a history of leaks and breaks; where leaks could cause the heaviest property damage; and where loads on the pipeline may exceed design loads (i.e. shallow pipes in high traffic areas). Once leaks are detected, repairs should be performed to eliminate them. Repair cost records should be kept for reference and to analyze costs associated with reducing water loss.

Operations staff did keep a record of unplanned discharges that occurred in 2015 in a spreadsheet. The spreadsheet indicates the following data: the address where the discharge occurred; the date the discharge occurred; the duration and estimated volume of the discharge; chlorine, pH, and turbidity results; implemented BMP; whether it was caused by a main or service leak; time when discharge was discovered; staff who arrived; who repaired the leak and when the repair was completed; the date repaired; the number of customers affected; cost of repair; cause of leak; and the corrective action. West Yost recommends this data continue to be documented and included in a GIS database when available. This information should also be considered when determining lost and unaccounted for water volume.

West Yost recommends that MPMW continue to track lost and unaccounted for water on a monthly basis with the goal of achieving less than 10 percent water loss. Continual tracking of water losses and repairs, meter replacements, and or/meter calibrations should be made to determine the extent of how one affects the other. Accurate meters typically provide the biggest impact on reducing water loss. Thus, a meter replacement program is recommended to replace all customer meters after they have reached a certain age usually 15 to 20 years. At this age, the meter accuracy would have diminished to the point that the cost of meter replacement is less than loss of revenues with continued use of the meter.

10.3.5 Emergency Planning

MPMW has a Water System ERP that was prepared in 2009. The ERP provides a standardized response and recovery protocol to prevent, minimize, and mitigate injury and damage resulting from emergencies or natural disasters and events caused by human intervention. Natural disasters include earthquakes, wild land fire, disruption of service, and destruction of property. Human intervention events include cross contamination, reservoir contamination, damage to equipment, explosives, mechanical equipment tampering, and power source interruption. The ERP provides direction on response to threats and terrorist scenarios identified in the vulnerability assessment (VA). The ERP currently includes the following information:

- Emergency planning process information including emergency planning partnerships, mutual aid agreements, and emergency response policies;
- Water system information including identification of emergency resources and alternate water sources;
- Standard Emergency Management System/Incident Command System;
- Concept of operations describing policies, procedures, and plans to mitigate emergency incidents;
- Communication procedures including chain of command, contact information, and notification procedures;
- Water quality sampling information and procedures;
- Emergency response, recovery, and termination phase descriptions; and
- ERP approval, update, training, and exercises.

The ERP was designed to comply with Section 1433(b) of the Safe Drinking Water Act as amended by the Public Health Security and Bioterrorism Preparedness and Response Act of 2002, California Government Code, the California Health and Safety Code, and the California Waterworks Standards.

MPMW is a member of the California Water/Wastewater Agency Response Network (CalWARN). The mission of CalWARN is to support and promote statewide emergency preparedness, disaster response, and mutual assistance matters for public and private water and wastewater utilities.

CalWARN provides member utilities with:

- An omnibus mutual assistance agreement and process for sharing emergency resources among members;
- A mutual assistance program consistent with other statewide mutual aid programs and the Standardized Emergency Management System (SEMS) and the National Incident Management System (NIMS);
- The resources to respond and recover more quickly from a disaster;
- A forum for developing and maintaining emergency contacts and relationships; and
- New ideas from lessons learned from previous disasters.

It is recommended that MPMW continue its membership in CalWARN and coordinate with other local and regional agencies (including San Mateo County and SFPUC) to ensure regional cooperation, especially as it relates to emergency preparedness.

A review of the ERP indicates the plan is currently out of date, references reports that have since been updated, and is missing pertinent data. The ERP requires regular updating when there are changes in any of the following: staff, contact information, prior to and following training sessions, and following updates to VA. Many of these changes have occurred since the ERP was originally written. In addition, exercises, drills, and training sessions should be conducted annually. According to operations staff, these activities have not occurred within the last two years. Also, as part of the plan update, the MPMW should consider an update of its water system VA.

MPMW's 2009 Water System ERP states that it will be updated regularly (at least annually) to ensure that the information is complete and accurate. Based on the date of the ERP that was provided to West Yost for review, it does not appear that the plan has been updated since 2009. There is no regulatory requirement to update the ERP; however, the plan should be updated as soon as possible to ensure that the information is complete and accurate. The following specific recommendations are made for the next update of MPMW's ERP:

1. Review and update contact lists and checklists.
2. Review and update, as needed, the appendices of the ERP (particularly Appendix A, phone lists).
3. Review and update, as needed, checklists for existing facilities to include facility improvements and/or any new facilities.
4. Reference in the ERP and be consistent with the State of California Emergency Plan dated July 2009. The State Emergency Plan addresses the state's response to extraordinary emergency situations associated with natural disasters or human-caused emergencies. In accordance with the State Emergency Plan, this plan describes the methods for carrying out emergency operations, the process for rendering mutual aid, the emergency services of governmental agencies, how resources are mobilized, how the public will be informed and the process to ensure continuity of government during an emergency or disaster.

5. Reference and acknowledge within the ERP the California Emergency Management Agency (Cal EMA). The Cal EMA was established as part of the Governor's Office on January 1, 2009 and was created by Assembly Bill 38 (Nava), which merged the duties, powers, purposes, and responsibilities of the former Governor's Office of Emergency Services with those of the Governor's Office of Homeland Security. Cal EMA is responsible for the coordination of overall state agency response to major disasters in support of local government. Cal EMA is responsible for assuring the state's readiness to respond to and recover from all hazards (natural, manmade, war-caused emergencies and disasters) and for assisting local governments in their emergency preparedness, response, recovery, and hazard mitigation efforts.
6. Include information on membership with CalWARN, including current contact information.
7. Reference and be consistent in the ERP with the San Francisco Bay Area Regional Emergency Coordination Plan (RECP). The RECP was published in March 2008 and was prepared in accordance with national and state emergency management systems and plans: in particular, the NIMS, the SEMS, the Master Mutual Aid Agreement, the California State Emergency Plan, and relevant mutual aid plans. The RECP does not supersede or exclude any of these concepts or plans; rather, it places them in the context of a response to an event in the Bay Area, during which time the Regional Emergency Operations Center is activated.

   The RECP builds on California's existing SEMS, through better definition of regional components of that system, including coordination across disciplines and levels of government, resource sharing, and regional decision-making. It also incorporates elements that previously have not been addressed in detail at the regional level under SEMS. The RECP comprises a Base Plan and nine subsidiary plans that address detailed elements for specific disciplines and operational activities.
8. Review and update system specific information (Section 3.1).
9. Include Pressure Boundary Map (missing from Section 3.2.2).
10. Review and update critical system components (Section 3.3).
11. Review and update alternative water sources (Section 3.4) as needed to reflect recent water system improvements. Review the operational status and condition of existing emergency interties.
12. Review and update Emergency Water Supply Calculations (Section 3.5).
13. Review and update Facility Emergency Equipment List (Section 3.6.1).
14. Include current City and MPMW organization charts and assignments (Section 4.3).
15. Review and update MPMW Chain of Command (Section 6.1).

16. Review and update notification procedures (Section 6.3), as needed. A description of any new available notification methods currently being used or being proposed (e.g., telephone alerts, text alerts, social media, etc.) should be added. Also, references to the California Department of Health Services (CDHS) need to be updated to the SWRCB.
17. Review and update the Appendix G templates of the ERP for Boil Water Order and other related public notices as needed to reflect updated contact information and agency contact information (e.g., CDHS is now SWRCB, OES is now Cal EMA, etc.)

It is recommended for the ERP to be updated as soon as possible to ensure that the City is adequately prepared to respond to an emergency should one occur. Following this plan update, the City should conduct a recommended training session for City staff to become familiar or reacquaint themselves with their emergency roles and responsibilities as described in a current plan. Subsequent to this plan update, it is recommended the plan be reviewed on an annual basis, updated as needed, and emergency exercises and drills be conducted.

Staff indicated that an emergency drill has not been conducted in the last two years. Regular training is recommended as a critical part of emergency preparedness. Training provides first responders, emergency management officials, private and non-governmental partners, and other personnel with the knowledge, skills, and abilities needed to perform key tasks required by specific capabilities. Training and exercises also help to identify and address deficiencies in existing procedures and protocols, so that they can be more effective in the event of an actual emergency.

The following recommendations are made with regard to emergency training, exercises and drills:

1. Upon completion of the update of the City's Water System ERP, and at the completion of subsequent plan updates, conduct a training session for City water management, administrative and operations staff to become familiar or reacquaint themselves with plan objectives and contents, as well as the emergency roles and responsibilities described in the plan.
2. Conduct an annual Tabletop Exercise with City water management, administrative and operations staff to review the plan and emergency roles and responsibilities.
3. Develop and conduct a biennial (every other year) Emergency Exercise with a simulated water system emergency scenario for City water operations staff to review/test emergency operations procedures (e.g., test procedures for activating emergency interties).
4. Develop and conduct an annual Communications Drill to review/test internal emergency communications procedures (e.g., within City Public Works Department and with other City departments) and external emergency communications procedures (e.g., with other agencies and with customers).
5. Figure 10-1 illustrates the key tasks in the emergency preparedness cycle, and Table 10-2 provides a summary of the recommended training program.

Figure 10-1. Emergency Preparedness Cycle

Table 10-2. Recommended Emergency Preparedness Training Program

Training Type	Objective	Participants	Frequency
Water System ERP Overview	Become familiar with and review plan objectives and contents, as well as the emergency roles and responsibilities described in the plan	City water management, administrative and operations staff	Upon completion of the update of the City's Water System ERP and at the completion of subsequent plan updates
Tabletop Exercise	Review the plan and emergency roles and responsibilities	City water management, administrative and operations staff	Annually
Emergency Exercise (with a simulated water system emergency scenario)	Review/test emergency operations procedures (e.g., test procedures for activating emergency interties)	City water management, administrative and operations staff	Biennially (every other year)
Communications Drill	Review/test internal emergency communications and external emergency communications procedures	City water management, administrative and operations staff City Public Works Department staff and other City department staff Other local and regional agencies Water customers	Annually

West Yost recommends the City coordinate its emergency planning, training and exercise efforts with other local and regional agencies (including San Mateo County and SFPUC) so that interagency and regional communications and coordination protocols can be exercised and modified as needed to ensure a coordinated response during an actual emergency. Many Bay Area counties conduct annual regional emergency drills and exercises in the month of October to coincide with the anniversary of the 1989 Loma Prieta earthquake. The City should coordinate with the County and others to actively participate in such regional emergency drills and exercises.

The City conducted a VA to consider water system vulnerabilities to man-made emergency and to review potential security improvements. This assessment was summarized is referenced in the City's 2009 Water System ERP. This VA was conducted per the requirements of the Bioterrorism Act.

While there are no specific requirements within the Bioterrorism Act to prepare an update to the City's Water System VA, the City may wish to review the findings and recommendations of the previously completed VA to ensure that recommendations have been successfully implemented to reduce the City's vulnerability to terrorist attack or other intentional acts and to defend against adversarial actions that might substantially disrupt the ability of the City's system to provide a safe and reliable supply of drinking water.

A Seismic VA was prepared for the MPMW in 2004 by G&E Engineering Systems. The Assessment recommended a Seismic Improvement Program to reduce adverse impacts on the water system. The recommendations included adding storage or well supplies to the lower elevation pressure zones by 2018. Since this study, the Sharon Heights booster pump station has been replaced and is assumed to be up to code for Seismic issues. Upgrades to the roof systems at the existing reservoirs was recommended. Staff indicate that roof replacement at the reservoirs is currently in the planning stages. To date, no additional storage has been added to the lower elevation pressure zones. In January 2013, the City Council authorized the design of the first emergency well and the design was recently approved for drilling in the lower zone at the MPMW's Corporation Yard. An update to the Seismic VA is being prepared as part of this WSMP System Master Plan. Specific recommendations have been developed as part of the Assessment update.

10.4 OPERATIONS AND MAINTENANCE STAFFING LEVEL ASSESSMENT

MPMW serves retail customers through approximately 4,300 potable water service connections over a seven-square mile service area. MPMW serves potable water to approximately 50 percent of the City.

MPMW requires O&M staff to perform the following services:

- Water system operations
- Grounds and facility maintenance
- General management
- Regulatory compliance
- Water quality sampling and reporting

- Customer service
- Safety training
- Inventory control
- Purchasing
- Follow-up meter reading and shut-off
- Annual cross connection testing on City owned backflow devices

MPMW is currently subcontracting out services for billing, cross-connection (backflow) testing for non-City backflow devices, large pipeline repairs, and large meter replacements.

MPMW currently employs three permanent, full-time operations staff members and two temporary operations staff members. Permanent staff are all state certified distribution and treatment operations personnel.

Temporary staff are hired through CalOpps, a public employment job board owned and operated by public agencies. Temporary employees are only able to work a maximum of 980 hours in a fiscal year to avoid paying for CalPERS benefits. This time restriction limits the responsibilities these workers can take on due to the fact that they will not be long-term employees. Also, the temporary employees typically have other jobs. In addition, each new temporary employee requires training which is time taken from permanent staff duties. The current temporary staff are not certified water operators which also limits the type of work they are allowed to perform.

MPMW requested a staffing analysis on the estimated work needs and the appropriate levels of staffing. Our assessment and recommendations are described in the sections below.

10.4.1 Existing O&M Staff Assessment

Existing O&M staff include three permanent certified water operators which include a Water System Supervisor, a Water Quality Specialist and a Water System Operator II. There is a new Senior Water System Operator position, but this is currently not budgeted. In addition, and on an annual basis, MPMW hires temporary laborers to support permanent staff. The current permanent and temporary staff responsibilities are described in detail for each position below.

10.4.1.1 Water System Supervisor

The Water System Supervisor position has many responsibilities with the main responsibility being supervising and overseeing the work completed by the permanent and temporary staff. Additional responsibilities include the following duties:

- Supervise, train, instruct, and motivate employees
- Prepare the daily log which tracks work order completion
- Review and assign new and outstanding work orders to staff
- Review and submit work order data entry by staff

- Review and respond to utility e-mail
- Coordinate with billing subcontractor
- Review plans for water system modifications, additions, and tie-ins
- Prepare parts list for water system tie-ins and placing material orders
- Conduct inspections of system facilities
- Investigate potential water leaks
- Investigate water quality issues
- Locate, inspect, repair and replace water meters
- Conduct inspections of construction activities
- Coordinate with construction contractors
- Monitor SCADA system and respond to alarms
- Complete and maintain a variety of records
- Prepare monthly staff reports
- Organize and conduct job and safety training
- Prepare Annual Water Quality Report
- Provide on-call duties for emergency responses
- Prepare annual budget and budget reviews
- Coordinate with contractors for water main repairs and emergency repairs
- Coordinate and track water meter and service line replacements
- Read and record SFPUC turnout meters (monthly)
- Review and track inventory (quarterly)
- Conduct staff performance reviews (annually)
- Attend meetings and coordinate with Engineering and Public Works staff
- Coordinate with the County on backflow inspections and repairs
- Conduct tasks of Water System Operator II and Water Quality Specialist as needed

10.4.1.2 Senior Water System Operator (not budgeted)

Under the direction of the Water System Supervisor, the Senior Water System Operator is responsible for assisting in the supervision of staff and for overseeing the more complex and difficult work associated with the construction, modification, maintenance, and repair of the water distribution system. Additional responsibilities include the following duties:

- Provides technical and functional direction to staff
- Reviews and controls the quality of work
- Performs complex and specialized water maintenance repair work
- Estimates costs of construction and maintenance work and supplies
- Orders supplies and equipment for work orders
- Monitors contractors
- Acts as the Water System Supervisor in his or her absence or as assigned

10.4.1.3 Water System Operator II

The Water System Operator II completes field work tasks and needs to be adept with customer interaction. Additional responsibilities include the following duties:

- Coordinate and complete fire flow testing
- Locate, inspect, repair, rebuild, replace, and reprogram water meters
- Locate, inspect, repair, rebuild, replace water services
- Replace meter boxes and lids
- Perform manual meter reads
- Investigate potential water leaks
- Locate water mains for paving projects
- Respond to on-call duties during emergencies
- Turn meters on/off
- Repair and replace fire hydrants
- Flush fire hydrants/blow-offs
- Leave customer door hangers/notifications
- Replace valve lids
- Conduct inspections of PRV stations
- Monitor SCADA system and respond to alarms

10.4.1.4 Water Quality Specialist

The Shift Operator/Water Quality Specialist completes field work tasks and needs to be adept in customer interaction. Additional responsibilities include the following duties:

- Investigate water quality issues
- Locate water mains and complete Underground Service Alert tags
- Investigate potential water leaks
- Collect water samples for testing
- Coordinate and complete fire flow testing
- Locate, inspect, repair, rebuild, replace, and re-program water meters
- Locate, inspect, repair, rebuild, and replace water services
- Fire hydrant repairs and replacements
- Fire hydrant/blow-off flushing
- Turn meters on/off
- Perform manual meter reads
- Investigate system pressure issues
- Leave customer door hangers/notifications
- Inspect SFPUC turnouts
- Monitor SCADA system and respond to alarms
- Provide on-call duties for emergency responses

10.4.1.5 Temporary Staff

The temporary staff are responsible assisting the permanent staff in addressing work orders and completing preventative maintenance duties. Additional responsibilities include the following duties:

- Locate and assist in water meter replacements and repairs
- Perform manual meter reads
- Clear meter boxes
- Replace meter boxes and lids
- Turn meters on/off
- Leave customer door hangers/notifications
- Assist in fire hydrant replacements
- Read and record SFPUC turnout meters (monthly)
- Control vegetation

10.4.1.6 Existing Staff Assessment

Discussions with MPMW staff and review of operating and maintenance information indicate that there is a shortage of staffing needed to complete day-to-day operations and complete preventative maintenance tasks. This is evident based on the maintenance review that was completed in Section 10.2 of this chapter. The maintenance review revealed several maintenance tasks are not being performed at all or are not being performed per recommended industry practices due to a lack of sufficient staffing resources. Existing staff are consistently overextended trying to keep up with current duties and overcompensating for the lack of sufficient staff. There is also turnover of temporary staff that requires time-intensive training of new staff by existing staff. MPMW currently only has staffing to perform the day-to-day operations, corrective maintenance needs, and some preventative maintenance tasks. MPMW staff noted that not all preventative maintenance tasks are being performed due to shortage of staff. Preventative maintenance is essential to extending the life of the MPMW water system infrastructure and identifying issues early to address problems before they affect customers and cannot be overemphasized.

MPMW has subcontracted its billing services which include meter reading and meter shut-offs for non-payment (only of units smaller than 3 inches). MPMW staff are responsible for meter shutoffs and reconnections of water meters 3 inches and larger. Staff also handle same day reconnection requests from customers. The subcontractor is responsible for next day reconnections of units 3 inches and smaller. MPMW staff are also responsible for completing maintenance items associated with manual meter re-reads and completing final meter readings that are requested by the subcontractor. Manual meter re-reads and final meter readings are completed by operations staff and accounted for 45 percent of work orders generated within the first eight months of 2015. These tasks appear to be a drain on current operations staff resources.

Operations staff receive approximately 60 to 100 work orders a month and each work order requires approximately 30 minutes of staff time to complete without travel time. Addressing work orders is anticipated to require approximately 30 to 50 hours of staff time each month. This amounts to nearly a full week of staff time addressing work orders. Each work order requires data be entered into a computer program for documentation purposes. A backlog of data is not uncommon due to a lack of office support and greater priority tasks associated with normal day to day operations. Documentation should be kept up to date if needed for reference and decision-making purposes. Current administrative staff support is shared with other City departments and is not sufficient. A full time administrative staff position is recommended to perform the necessary documentation and reporting duties associated with the water system and to free up Water System Supervisor time associated with office duties.

The Water System Supervisor indicates he typically spends 40 hours a week in the office and 15 to 20 hours a week outside of the office, not including requirements for on-call shifts. This type of consistently intense work schedule can often lead to employee burnout and turnover. The position of Water System Supervisor is an important one as they are responsible to make sure the system operates smoothly and that day–to-day tasks are being completed. The Water System Supervisor has gone above and beyond to ensure that day-to-day duties and corrective tasks are being completed in a timely manner, but cannot be expected to continue under the current lack of staffing resources on a long-term basis.

On-call services are alternated weekly through each system operator. Each operator is needed for on-call duties twice in a four-week period because there are only a total of three certified operators available. This can also be problematic due to the amount of off-duty time that each operator is required to remain available to perform these duties. The on-call availability requirement limits employee off-duty time and travel. For example, when someone is required to be on call after hours then they cannot leave town and/or make outside time commitments because they must be able to respond to emergency situations quickly. Note that on-call duties require staff to be available 24 hours a day, 7 days a week regardless of holidays.

Temporary staff are hired through CalOpps. Temporary employees are only able to work a maximum of 980 hours in a fiscal year. This time restriction limits the responsibilities these workers can take on due to the fact that they will not be long-term employees. In addition, each new temporary employee requires training which is time taken from permanent staff duties. The current temporary staff are not certified water operators which limits the types of work they are allowed to perform.

10.4.2 Comparison to Similar Size Utilities

A comparison of water utility operations and maintenance staffing was completed for similar size utilities. This is a general comparison based completely on utilities of similar size. There may be variations on actual operator duties that are specific to each utility. For example, some utilities may have different infrastructure maintenance requirements due to the number, type, and complexity of distribution facilities. These factors have not been accounted for in this comparison. Table 10-3 includes a list of the selected water utilities and their approximate size based on the number of service connections and population. System population and water service data were obtained from the Safe Drinking Water Information System records database.[5] Water utilities of equal size were chosen including several neighboring BAWSCA members. Each water utility was contacted requesting their O&M staffing organizational chart. The data received from the responding utilities is summarized in the Table 10-3.

[5] https://sdwis.waterboards.ca.gov/PDWW/

Table 10-3. Utility Staffing Survey for Utilities of Similar Size to MPMW

Utility Name	Location City/County	Population Served 3	No. of Water Services 3	Type of Operator (Qty)[(a)]
MPMW	Menlo Park, CA	16,100	4,202	Water System Supervisor (1) Water System Operator II (1) Water Quality Specialist (1) Temporary Staff (2)
Neighboring BAWSCA Agencies				
City of East Palo Alto	East Palo Alto/ San Mateo	38,000[(b)]	3,752	Chief Operator/Engineer (1) T2/D2 – T5/D5 Operators (4)
Town of Hillsborough Water Division	Hillsborough, CA/ San Mateo	11,260	3,880	Water Division Supervisor (1) Water Quality Technician (1) Lead Workers (2) Maintenance Workers (5)
Other Similar Size Water Utilities in California				
Carpinteria Valley Water District	Carpinteria, CA/Santa Barbara	16,050	4293	O&M Manager (1) Water Utility Foreman (1) Water Treatment Operator (1) Water Utility Worker I (1) Water Quality/Customer Service (1) Water Utility Helper (1)
City of Lomita	Lomita, CA/ Los Angeles	20,300	4,176	T4/D2 Treatment Operator (1) D2/T1 Sr. Maintenance Worker (1) D2 Maintenance Worker (1) D3/T3 Maintenance Worker (1) D4/T3 Contract Operator (2)
Nipomo Community Services District	Nipomo, CA/ San Luis Obispo	12,512	4,284	Water Supervisor (1) Utility Workers (3) Maintenance Worker/Customer Service (1)
Trabuco Canyon Water District	Trabuco Canyon, CA/Orange	14,900	3,962	D4/T3 Water Superintendent (1) D5/T4 Chief Plant Operator (1) D4/T3 Operator (1) D4/T4 Operator (1) Maintenance Superintendent (1) Maintenance Technician (2)

(a) Data provided in utility organization charts.
(b) Population estimate appears to be in error based on 2013 Census Bureau reported population of 29,143.

According to the 2014 Annual Report to the Drinking Water Program (submitted to the State of California Division of Drinking Water), MPMW currently serves a population of approximately 16,100, with 4,202 water services. In comparison to similar size utilities, the current MPMW staffing is lacking in full-time certified operator positions. The similar size water utilities have a range of five to nine full-time O&M staff, including the Water System Supervisor. Taking an average of the staffing level in the six utilities shown in the table above results in approximately seven full-time O&M staff.

10.4.3 Recommendations

The existing staff assessment and utility comparison indicate that the current MPMW staffing is insufficient to provide the day-to-day operations and perform necessary preventative maintenance tasks as recommended in Section 10.2 of this Chapter. The maintenance review provided clear evidence that existing staffing is inadequate to meet the maintenance needs of the water system. Existing staff are overextended trying to keep up with day-to-day operations, corrective maintenance, and on-call duties and are at serious risk of burnout and turnover. When turnover of existing staff occurs frequently the training of new staff can be cost and time intensive for existing remaining staff. Also without proper historical documentation to reference, new staff will struggle with understanding system processes and quality of service may be reduced.

An analysis of the estimated staff time needed to complete current day–to-day duties and recommended preventative maintenance tasks was performed. The estimated staff time was divided by the available hours of a full-time employee to determine the number of estimated full time employees needed to complete day-to-day duties and preventative maintenance tasks. Many of the task estimate assumptions were based on MPMW's 2015 work order log. A breakdown of estimated staff time by task is provided in Table 10-4. The conclusion of this analysis recommended six and a half full time employees. Some of the tasks included in the analysis could be completed by an administrative person such as work order documentation, inventory and purchasing.

This analysis did not include anticipated future tasks associated with a proposed new emergency well and implementation of a recycled water program. West Yost recommends a total of seven full-time employees to account for some of the additional duties associated with the proposed well. Additional staffing beyond seven may need to be considered depending on the complexity of well operations. The current full-time staff will fill three of these positions, leaving four remaining. West Yost recommends that, at a minimum, three of those open positions be filled with experienced certified water operators that have certification levels similar to existing staff. In addition, MPMW is currently evaluating the feasibility of a recycled water program. If a recycled water program is implemented additional staff will be needed to oversee design and construction and to operate and maintain the recycled water system.

The MPMW system holds a D3 Classification status. According to the distribution system staff certification requirements of the California Code of Regulations, Chapter 13, Article 2, a D3 distribution system requires a minimum Water System Supervisor (chief operator) certification of D3 and a shift operator certification of D2. Current operations staff hold T2/D4 certifications. Current temporary part-time employees are recommended to be replaced with full-time certified distribution and treatment operators. It is important for potential operators to have both treatment and distribution certifications to be able to provide additional help with future well sampling and fill-in for the existing Water Quality Specialist when needed. An operator with experience in groundwater well water quality sampling and operations will be important once MPMW's planned emergency well is operating. The additional workload associated with the O&M of the new standby emergency well should be considered when looking at future staffing needs. An operator with well head treatment plant experience may be desirable if well head source water treatment beyond chloramination and fluoridation is required to meet regulatory limits.

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Table 10-4. Staffing Level Assessment Summary by Task

Full time Available Work Hours Estimate			Tasks	Assumptions	Estimated Annual Hours	
12	Months		Utility Marking	40 per month, 2 a day for 20 days a month, 2 hrs each with travel	960	9%
40	Hours per Week		Work Order Documentation	1 hours a day for 20 days a month	240	2%
2080	52 Weeks a Year		SFPUC Meter Reading	once a month, 3 hours with travel	36	0%
2080	Hours per Year		Meter Maintenance	12 meters per month, 4 hours each	576	5%
			Meter/Service Replacements	10 per month, 2 employees 8 hours each	1920	18%
11	Paid Holidays	Floating Holiday	Pump Station Inspections	once a day, 20 days a month for one hour	240	2%
88	Hours per Year	**30** Hours per Year	Pump Station Maintenance	8 hours a month	96	1%
			Generator Inspection and Testing	6 hours a month	72	1%
	Sick Time Days		Reservoir Inspections	once a day, 20 days a month for one hour	240	2%
8	Hours per Month		Reservoir Maintenance	4 hours a month	48	0%
96	Hours per Year		Cross-Connection Testing	50 units per year, 1.5 hr per unit to test and document	75	1%
			PRV Inspections	1.5 hours per day with travel, 20 days a month	360	3%
	Vacation Time		PRV Maintenance	6 hours every 6 months	12	0%
88	Hours per Year	1st Three years	Hydrant Inspection	1.5 a day at 1.2 hours for 20 days a month	288	3%
104	Hours per Year	3-5 Years	Hydrant Testing	3 hydrants a week at 3 hours each with documentation	432	4%
			Hydrant Replacement/Repair	1.5 per month, 2 employees at 8 hours each	288	3%
	Personal Business Leave		Dead-end Flushing	5 a month at 4 hours each with documentation	240	2%
3	Days per Year		Valve Exercising & Maintenance	7 a week at 1 hour each	336	3%
24	Hours per Year		Valve Repair/Replacement	1 every other month, 2 employees at 4 hours each	48	0%
			Water Quality Sampling & Documentation	15 hours a week	720	7%
Total Available Work Hours per Full-time Employee Per Year			Certification Training	16 hours a year for 5 employees	80	1%
			Safety and Computer Training	8 hours a month for 5 employees	480	4%
1738	3-5 Years		Updates to ERP/ Annual Training Drills	8 hours a year for 5 employees	40	0%
1754	1st 3 Years		Repair Water System leaks	7 per month at 4 hours each	336	3%
			Regulatory & Monthly Reporting	6 hours a month	72	1%
			Staff & Field Meetings	20 hours a month for 2 employees	480	4%
			SCADA Monitoring	8 hours a month	96	1%
			Meter Rereads/Shut-offs	80 per month at 1 hour each	960	9%
			New Construction Inspections	8 hours a month	96	1%
			Inventory and Purchasing	3 hours a week	144	1%
			Field Equipment and Vehicle Maintenance	5 hours a month	60	1%
			Coordination with Subcontractors	3 hours a week	144	1%
			Vegetation Maintenance (Meter boxes and facilities)	30 per month at 1.5 hour each	540	5%
			Customer Service	4 hours a week	192	2%
			Performance Reviews	8 hours once a year	8	0%
				Total	**10955**	**100%**

Estimated Number of Full time Employees **6.2 Assumes Staff in 1st 3 years of service**
6.3 Assumes Staff in 3-5 years of service

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West Yost recommends that there be a minimum of six qualified operators to alternate on-call duties so each operator doesn't have to be available more than one week every six weeks. An office/administrative employee is recommended to complete administrative type duties like documentation, inventory management, purchasing, and reporting. This type of employee would provide essential support to the operations staff allowing existing operations staff more time to focus on field work.

Preventative maintenance is essential to extending the life of MPMW water system's infrastructure. The costs associated with the consequences of not providing the necessary preventative maintenance can be much greater than the additional cost to implement a successful preventative maintenance program.

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APPENDIX A

Final Submittal for Water System Geographic Information System Update

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TECHNICAL MEMORANDUM

DATE:	January 20, 2017	Project No.: 648-12-15-01 SENT VIA: EMAIL
TO:	Azalea Mitch, City of Menlo Park	
CC:	Whit Loy, City of Menlo Park	
FROM:	Mandy Ott, EIT #157201 Roberto Vera, PE, RCE #83500	
REVIEWED BY:	Polly Boissevain, PE, RCE #36164	
SUBJECT:	Final Submittal for Water System Geographic Information System Update	

The purpose of this Technical Memorandum (TM) is to document the tasks West Yost Associates (West Yost) performed to update the Menlo Park Municipal Water District's (MPMWD) Water System Geographic Information System (GIS). The scope of this effort generally consisted of:

- Completing a pilot study used to identify any obstacles in the field that would impact the system-wide field investigation;
- Updating water utility GIS files using Global Positioning System (GPS) points collected during system-wide field verification, photo collection of various facilities, and mark-ups from City Staff;
- Completing and correcting a GIS topology of the water utility features for compatibility with the water modeling phase;
- Creating a new mapbook for display of the City water utilities at a 1-inch = 120-foot scale; and
- Updating all water utility GIS files using an agreed upon geodatabase template as recommended by ESRI and customized for the City.

This TM references various items to be included in a separate electronic submittal, which are summarized in the *Overall Water System GIS Update Electronic Submittal* section at the end of this TM. The following sections summarize the overall tasks performed to update the City's Water System GIS.

- Pilot Study
- Photographic Documentation
- GIS Updates
- Geodatabase Updates

- Mapbook Update
- Overall Water System GIS Electronic Submittal

PILOT STUDY

Prior to beginning the system-wide field verification, a pilot study was conducted in two pilot areas (i.e., a "Difficult Area" and a "Common Area") in an effort to bracket the range of the expected conditions. In addition, the study was conducted to determine the adequacy of using the Trimble Geo7x™ (centimeter edition) and the Trimble GeoXT 2008™ (sub-meter edition) hand-held GPS for logging points and collecting data. The overall pilot study protocol was documented in *City of Menlo Park Water Distribution System – Pilot Study Protocol for Field Data Collection* by West Yost (August 21, 2015).

After conducting the Pilot Study, West Yost identified and recommended field protocol changes and GIS data collection changes, which were subsequently used for the system-wide field investigation. Field protocol changes were recommended in an effort to save time; such changes included the City not needing the location of hydrant valves (since all of the City's hydrants have an isolation valve) and the definition of the number and type of photos that needed to be taken. Similarly, GIS data collection changes were made in an effort to save time in the field and reduce the amount of data processing required once the data was being compiled into the geodatabase. An example of this is providing clear definition of what "standard" attributes were so that they could be pre-programmed into the GPS handheld unit. The pilot study also proved that the Trimble Geo7x™ produced higher-quality GPS points, and was faster to use, collect points and post-process data. As a result, West Yost recommended that a Trimble Geo7x be exclusively used for the system-wide field verification in an effort to streamline data collection and post-processing.

PHOTOGRAPHIC DOCUMENTATION

As part of the field verification effort, photographic documentation (photo(s) of customer service meters and various other water system facilities) was gathered in an effort to help City Water Operations staff locate facilities faster. Originally, it was planned that three photos at each of the customer service meters and one photo for each hydrant be collected. However, results from the pilot study found that a single photo at customer service meters was sufficient, and that hydrants only needed photo documentation in areas where their location is not obvious. Photos of valves, water sampling stations, and blow-offs were also collected on a case-by-case basis at the discretion of the field teams. The field teams marked the water feature with orange utility flags to help focus the photos.

The collected photos are being submitted as part of the electronic submittal. Photos for customer service meters are organized in folders by street name (e.g. Sage) and then if applicable, in sub-folders by block (e.g. 1400 Sage). The individual photos are named with the customer service address (e.g. 1405 Sage.jpg) and generally include/contain details such as: overall context, address sign (if possible), and a utility flag marking where the customer service meter is in relation to the property. Photos for valves, hydrants, sampling stations, and blow-offs are contained in a separate folder and are not organized in sub-folders. Instead, they are titled with street names and a sequential number (e.g., Market Valve.jpg, Market Valve (2).jpg). Similar to the water meter photos, the water facility is marked with an orange utility flag to call attention to it.

GIS UPDATES

West Yost spent approximately 11 weeks surveying throughout the City's service area, using the Trimble Geo7x™ (centimeter) hand-held GPS units, collecting data for: valves, meters, hydrants, backflows, USA marks, and any other identifiers useful for spatially realigning the water mains. Field-collected points were then post-processed and projected to NAD 1983 California State Plane Zone III horizontal datum for importing into GIS. Elevations were projected to NAVD 1988 (mean sea level) vertical datum. These points then served as the basis for developing a new water main file; built from the original water main file (in order to retain pipe information like diameter and material) but realigned/adjusted to best fit with field-verified points.

For areas where water utility configurations were still questioned, the City provided supplemental field work and mark-ups for clarification. It should be noted that the locations of water mains and laterals developed as part of the geodatabase and shown on the resulting mapbooks were adjusted/realigned to best fit (where applicable):

- Field-collected points;
- Old GIS alignments;
- City-provided as-built drawings, and;
- City-provided schematic mark-ups.

Alignments shown on the mapbook and contained in the geodatabase may still differ from actual field conditions. The mapbook and geodatabase was developed for planning purposes and were not intended for design, construction, or similar activities. In addition to realigning/adjusting the water main feature classes to the field-verified points and City provided drawings and mark-ups, a topology analysis (using the ESRI topology tools) was performed to correct any water utility connectivity errors. Geodatabase topology checks are used to ensure data integrity by validating and identifying errors where feature classes may not represent real-world conditions, such as:

- Segments of water main must not self-overlap nor should different segments overlap each other.
- Water mains should connect at any junction meant to represent a tee or cross.
- Valves must be connected to a water main or a water lateral.

All errors were corrected within the City service area. Features included in the topology analysis were:

- Water Mains,
- Water Laterals,
- System Valves,
- Control Valves,
- Backflow Preventers,
- Hydrants, and
- Water Fittings.

For purposes of the planned hydraulic model development from the GIS, water mains were broken at all crosses and tees (excluding pipe jumps), diameter changes, system valves, and control valves. Table 1 references the rules and nomenclature defined by ESRI and used for the topology analysis.

Table 1. Topology Rules

Primary Feature Class	Rule	Secondary Feature Class	Rule Definition
Water Mains	Must Not Overlap	-	Lines must not overlap any part of another line
Water Mains	Must Not Self-Overlap	-	Lines must not overlap themselves
Water Mains	Must Not Self-Intersect	-	Lines must not cross or overlap themselves
Water Mains	Must Not Have Dangles	-	The end of a line must touch any part of one other line
Water Mains	Must Be Single Part	-	Lines must only have one part
Water Laterals	Must Not Overlap	-	Lines must not overlap any part of another line
Water Laterals	Must Not Self-Overlap	-	Lines must not overlap themselves
Water Laterals	Must Not Overlap With	Water Mains	Lines must not cross or overlap themselves
Water Laterals	Must Not Self-Intersect	-	Lines must not overlap any part of another line
Water Laterals	Must Be Single Part	-	Lines must only have one part
Control Valves	Must Be Disjoint	-	Points cannot overlap within the same feature class
Control Valves	Must Be Covered By Endpoint Of	Water Mains or Laterals	Points in one feature class must be covered by the ends of lines in another feature class
System Valves	Must Be Disjoint	-	Points cannot overlap within the same feature class
System Valves	Point Must Be Covered By Line	Water Mains or Laterals	Points in one feature class must be covered by lines in another feature class
Hydrants	Must Be Covered By Endpoint Of	Water Laterals	Points in one feature class must be covered by the ends of lines in another feature class
Hydrants	Must Be Disjoint	-	Points cannot overlap within the same feature class
Backflows	Must Be Covered By Endpoint Of	Water Laterals	Points in one feature class must be covered by the ends of lines in another feature class
Backflows	Must Be Disjoint	-	Points cannot overlap within the same feature class
Water Fittings	Must Be Covered By Endpoint Of	Water Mains	Points in one feature class must be covered by the ends of lines in another feature class
Water Fittings	Must Be Disjoint	-	Points cannot overlap within the same feature class

Note: For topology, the Water Mains feature class did not include Non-City of Menlo Park mains.
For further information on topology rules, see the ESRI Topology Rules Poster at:
http://webhelp.esri.com/arcgisserver/9.3/dotNET/index.htm#geodatabases/topology_rules_poster.htm

Assumptions

Although GPS coordinates of most of the point water features within the City were collected, the water mains feature class still hosts a degree of error. For example, a common item that was encountered while rebuilding the GIS was determining whether a valve was on a main water pipe or on a lateral. As a result, the final water main feature class was built by comparing field-verified points with original City mapping and educated assumptions. Some assumptions that were made by West Yost and not verified in City supplemental efforts are documented in Attachment A. These maps are intended to document these assumption areas for the City to address or confirm as they continue to refine their GIS data.

GEODATABASE UPDATES

The City's water utilities were compiled into a single GIS geodatabase (MenloPark_Water_Utilities.gdb), which is a collection of various feature classes within a feature dataset sharing common geographic information, such as a coordinate system, and pre-defined domains. Feature classes included in the final water utility geodatabase are:

- WtBackflow,
- WtControlValve,
- WtDistrictBoundary,
- WtFacility,
- WtFitting,
- WtHydrant,
- WtLateral,
- WtMain,
- WtMeter,
- WtSamplingStation,
- WtSystemValve, and
- Easement (empty feature class – built for future use).

The data fields for each water utility feature class were initially based on the ESRI water utility template. The field verification effort collected asset information for each facility (e.g., hydrant manufacturer, water feature diameter, meter manufacturer), using this original template. However, data fields were subsequently refined and customized to meet the requirements requested by the City. In addition to the data fields, certain domains and subtypes were defined and further customized, based on City input. GIS domains and subtypes are useful for creating rules that allow only legal values of a field type. Domains constrain input information to allow for only pre-determined values for entry, helping to maintain the integrity and consistency of the database. Subtypes are specific to a feature class and are used to categorize data. All data fields, data types, domains, and subtypes for each water utility feature class are outlined in the provided

Excel database: GDB_Structure_Final.xlsx, included as an electronic file and in Attachment B.[1] Data fields within each feature class were linked to either data collected during field work, original City GIS fields (where data were available), or left blank for intended future use.

In addition to populating the feature class attributes, all water utility feature classes were also given a new unique identification (Facility ID) based on the type of feature and location. Facility IDs were created using the following naming convention:

Mapbook grid page – Facility Prefix + Zone Abbreviation – Sequential Number

Where, Zone Abbreviations are defined as:

Upper = U

Lower = L

High Pressure = H

Table 2 summarizes the nomenclature used for facility identification prefixes for only those features currently existing in the final geodatabase. An electronic copy of the Excel spreadsheet that lists all of the Facility IDs currently being used in the geodatabase is provided as part of the electronic submittal. This spreadsheet is intended to help the City maintain a unique Facility ID, as the City populates the geodatabase with new features, so as to not repeat IDs that have already been used.

Supplemental feature classes are also provided as part of this submittal in a separate geodatabase (MenloPark_Generic.gdb). This geodatabase includes the following feature classes:

- Assumptions (corresponding to the figures in Attachment A),
- City_Parcels,
- MapGrid (the original City mapbook grid), and
- MapGrid_Quads (the original City mapbook grid split into quads to allow for the 1-inch = 120-foot scale of the final mapbook).

[1] It should be noted, that in addition to the domains and subtype, annotations classes and associated links were also originally planned. However, after reviewing with the City and the Lynx Technologies (Lynx is the City's GIS consultant), the City plans to label the mapbook based on the "GIS Asset ID", which is not yet developed and is to be completed by Lynx. These annotation classes will be developed after the Water Geodatabase gets integrated with the City's larger GIS update.

Table 2. Facility Identification Nomenclature

Feature Class Name or Subtype	Facility ID Prefix
System Valves	
All System Valves	V
Control Valves	
Air Release Valve	AR
Blow-Off Valve	BO
Pressure Reducing Valve	PRV
Intertie	I
Turnout	TO
Unspecified	CV
Facilities	
Pump Station	PS
Storage Basin	R
Water Fittings	
Cap	FT
Water Meters	
Water Meters	WM
Hydrants	
Hydrants	FH
Backflow Preventers	
Backflow Preventers	BF
Sampling Stations	
Sampling Stations	SS
Water Mains	
Water Mains	P
Water Laterals	
Water Laterals	WS

Geometric Network

The feature classes listed above were used as the data sources to define a geometric network. Within the feature dataset are also a dynamic point file: Water_Network_Junctions and the geometric network connectivity definition: Water_Network; together defining the geometric network. The geometric network is a set of connected edges (lines) and junctions (points) that represent the behavior of a real-world system using defined connectivity rules. The intent of the geometric network is to make sure that new features added to the geodatabase are done so in a consistent manner, based on how the City plans to maintain the geodatabase and represent their water system in GIS. As a result, the Water_Network has been created but does not contain connectivity rules that constrain how features are defined and drawn. This will need to be decided by the City so that it is consistent with the overall GIS program (e.g., sewer utilities, storm drain facilities, etc.) and accommodates the asset management program, as it continues to develop.

MAPBOOK UPDATE

After all the edits to the water main feature class and resulting geodatabase were made, a new mapbook was created. West Yost used the City's existing grid file, but further divided each grid into quadrants, resulting in a mapbook that displayed City water utilities at a 1-inch = 120-foot scale. This was done at the request of the City, to more clearly show the various water system facilities. A hard copy of this mapbook will be provided to the City separately. An electronic copy will be submitted as part of the electronic submittal.

OVERALL WATER SYSTEM GIS UPDATE ELECTRONIC SUBMITTAL

The overall electronic submittal for the update to the City's Water System is provided in a disk/external hard drive and includes the following:

- Electronic PDF of the final mapbook, including an overall Grid Index figure
- Electronic Geodatabases
  - MenloPark_Water_Utilities.gdb
  - MenloPark_Generic.gdb
- Electronic Excel database of all Facility Identifications used
- Electronic Excel database of the geodatabase structure, including domains and subtypes
- Electronic Map Package of the final mapbook
- Photos of the City's customer service meters, and various hydrant, valve and water sampling location.

ATTACHMENT A

Assumption Figures

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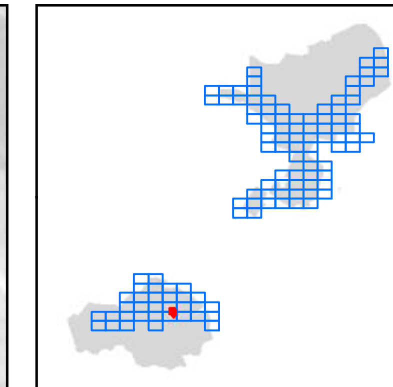
Mapbook Page(s): B16-4, B17-2
City noted this as a private area on their mark-ups but lateral configuration and connection to the main was assumed.

Notes:
1. During final processing, West Yost Associates (WYA) collaborated with the City of Menlo Park on questions regarding water facility configurations. These figures represent areas in which WYA made assumptions greater than the overall assumption of moving the water main to match field verified facilities.



0 30 60
Scale in Feet

Symbology

- Water Meter (14)
- Water Valve, Open (7)
- Water Valve, Closed (2)
- Fire Hydrant (2)
- Backflow Preventer (8)

Processed Water Mains

- Menlo Park, Active
- Hydrant Lateral
- Service Lateral
- Parcels
- Menlo Park District Boundary
- Areas where Configuration was Assumed by WYA

CITY OF MENLO PARK

WEST YOST ASSOCIATES

Assumption 1

Assumptions by WYA during Final Processing

City of Menlo Park
Water System Master Plan

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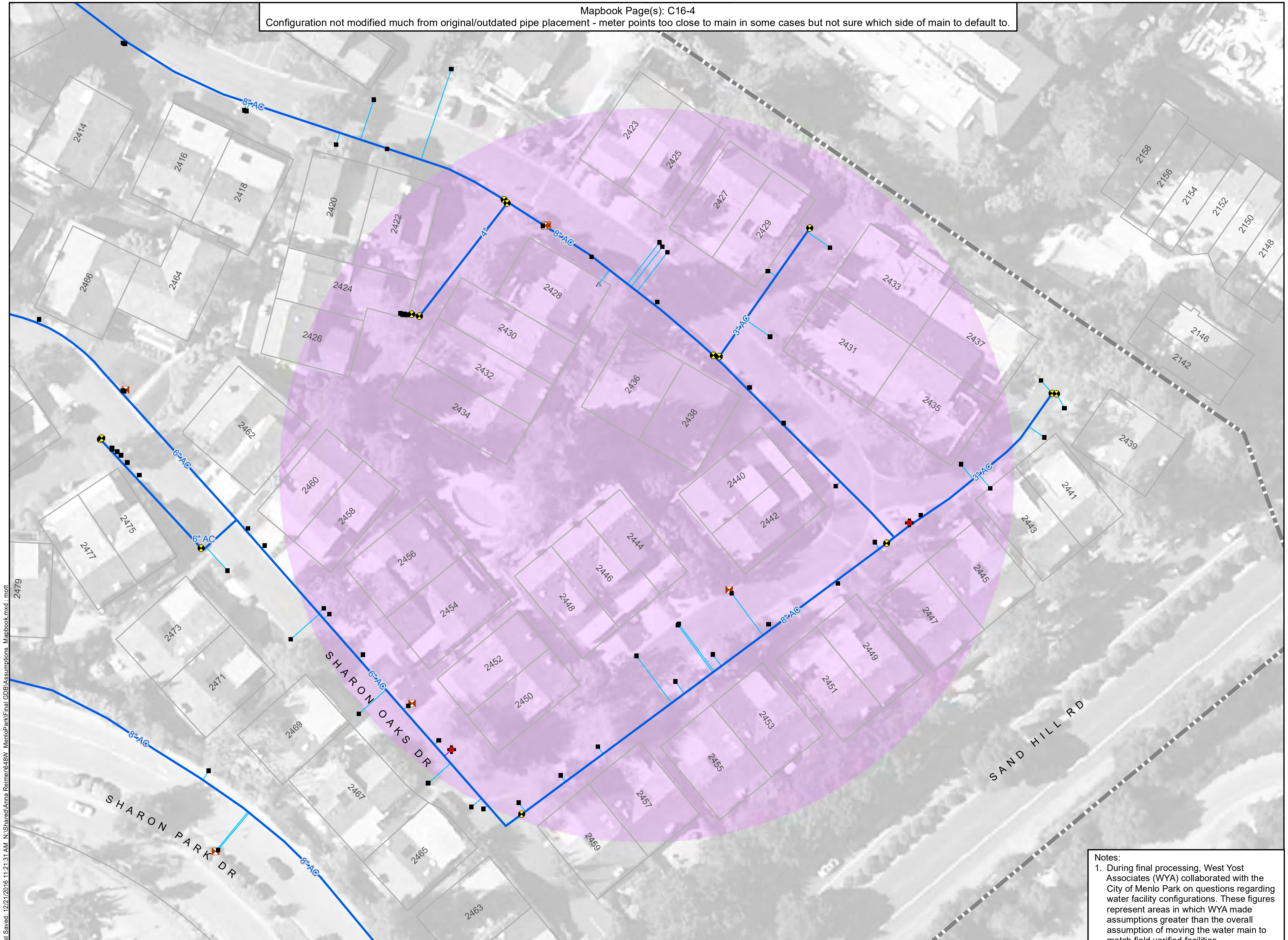

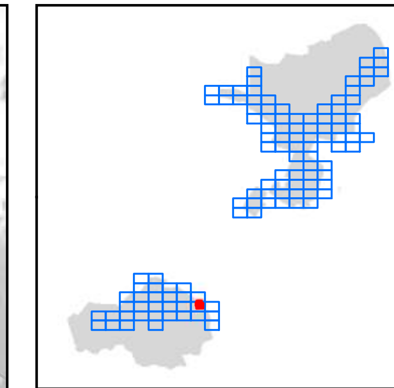

0 25 50
Scale in Feet

N

Symbology

- Water Meter (67)
- Water Valve, Open (14)
- Fire Hydrant (2)
- Backflow Preventer (6)

Processed Water Mains

- Menlo Park, Active
- Hydrant Lateral
- Service Lateral

City Provided Facilities

- Sampling Station
- Parcels
- Menlo Park District Boundary
- Areas where Configuration was Assumed by WYA

CITY OF MENLO PARK

WEST YOST ASSOCIATES

Assumption 2

Assumptions by WYA during Final Processing

City of Menlo Park
Water System Master Plan

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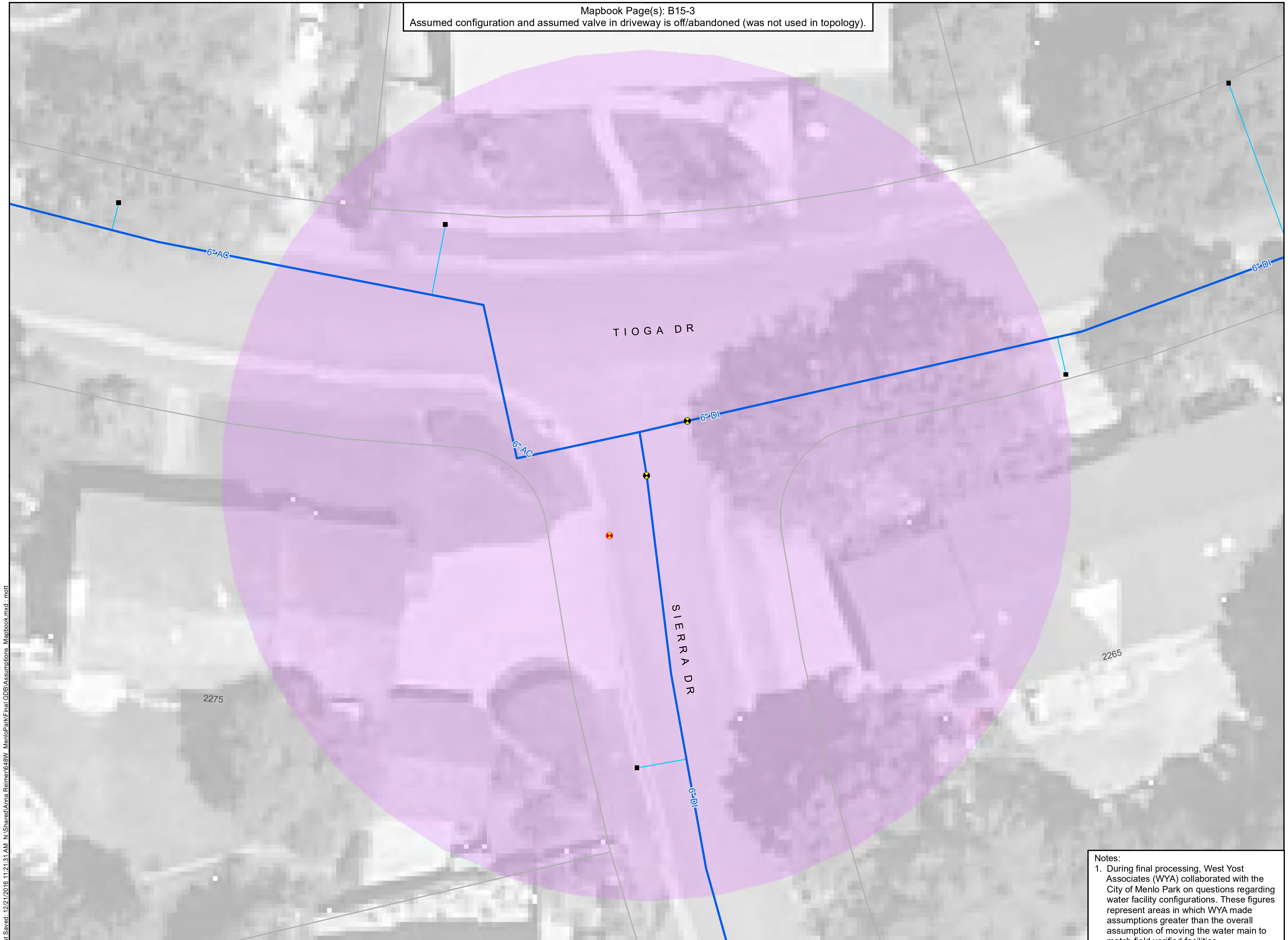
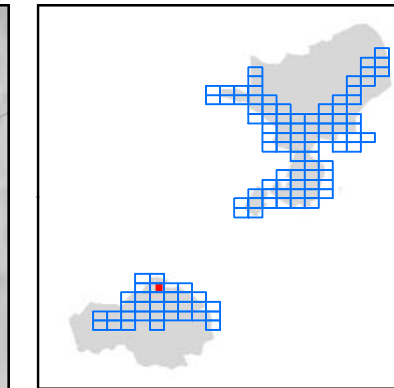
Mapbook Page(s): B15-3
Assumed configuration and assumed valve in driveway is off/abandoned (was not used in topology).



Notes:
1. During final processing, West Yost Associates (WYA) collaborated with the City of Menlo Park on questions regarding water facility configurations. These figures represent areas in which WYA made assumptions greater than the overall assumption of moving the water main to match field verified facilities.



0 5 10
Scale in Feet

N

Symbology

- Water Meter (5)
- Water Valve, Open (2)
- Water Valve, Closed (1)

Processed Water Mains

- Menlo Park, Active
- Service Lateral
- Parcels
- Menlo Park District Boundary
- Areas where Configuration was Assumed by WYA

CITY OF MENLO PARK

WEST YOST ASSOCIATES

Assumption 3

Assumptions by WYA during Final Processing

City of Menlo Park
Water System Master Plan

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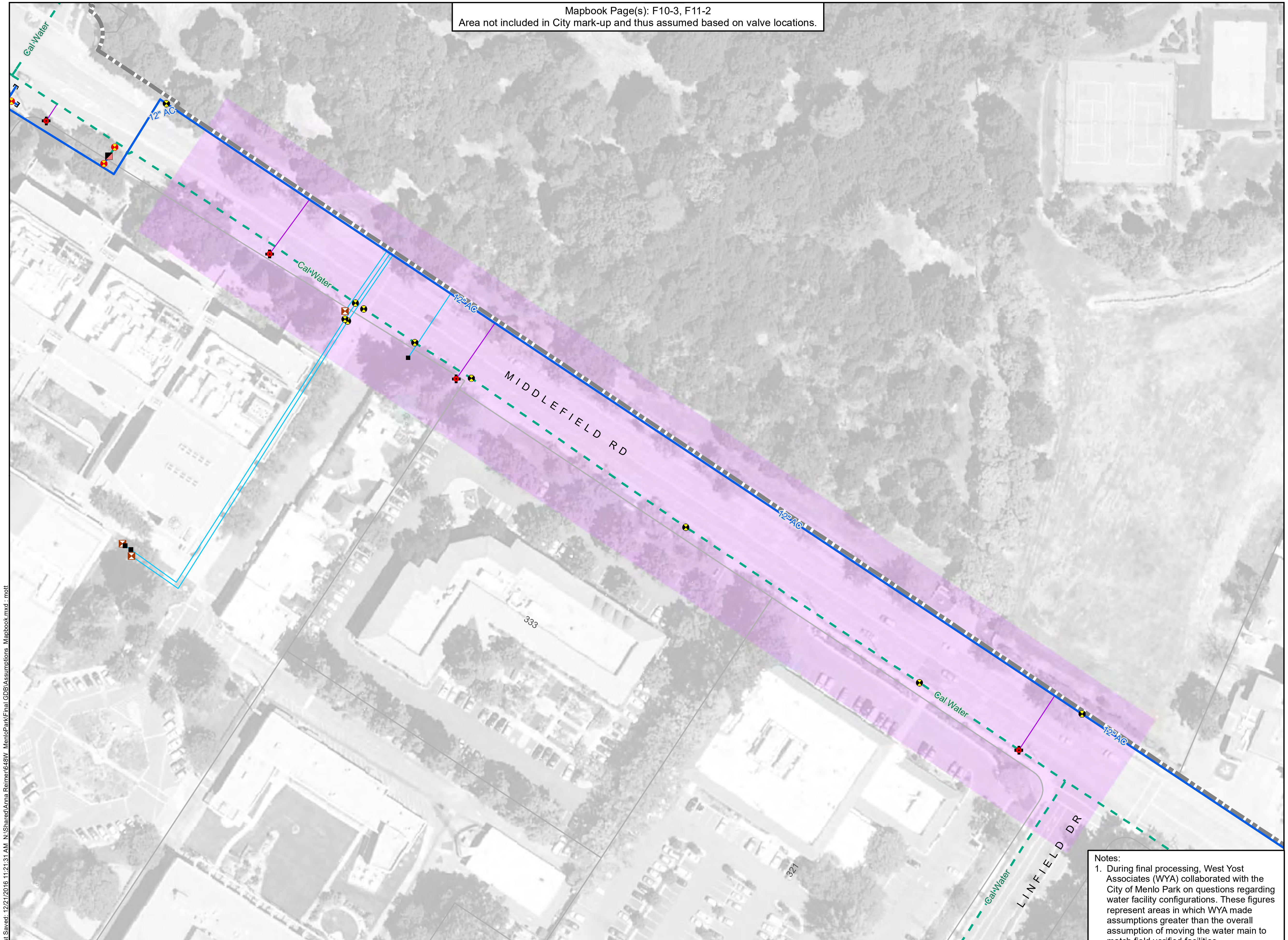
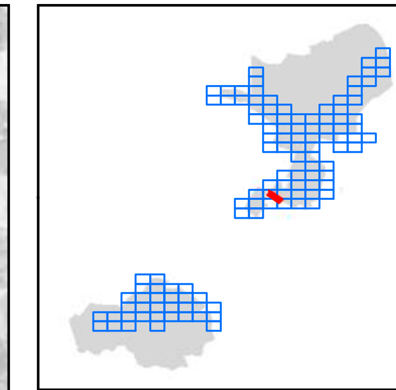
Mapbook Page(s): F10-3, F11-2
Area not included in City mark-up and thus assumed based on valve locations.





0 40 80
Scale in Feet

N

Symbology

- Water Meter (3)
- Water Valve, Open (12)
- Water Valve, Closed (3)
- Intertie (1)
- Fire Hydrant (4)
- Backflow Preventer (3)

Processed Water Mains

- Menlo Park, Active
- Non-City of Menlo Park
- Hydrant Lateral
- Service Lateral
- Cap Fitting
- Parcels
- Menlo Park District Boundary
- Areas where Configuration was Assumed by WYA

Notes:
1. During final processing, West Yost Associates (WYA) collaborated with the City of Menlo Park on questions regarding water facility configurations. These figures represent areas in which WYA made assumptions greater than the overall assumption of moving the water main to match field verified facilities.

CITY OF MENLO PARK

WEST YOST ASSOCIATES

Assumption 4

Assumptions by WYA during Final Processing

City of Menlo Park
Water System Master Plan

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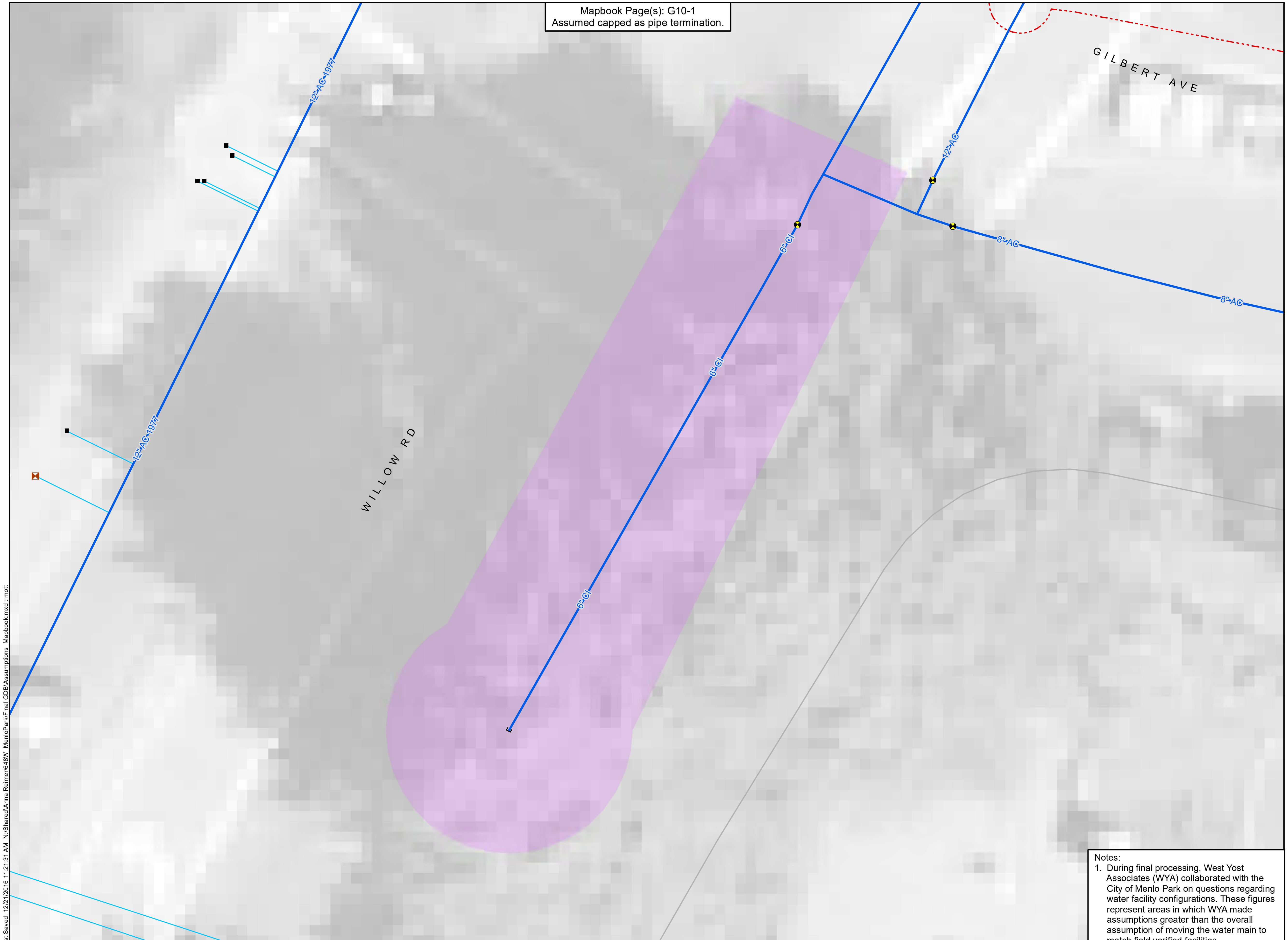
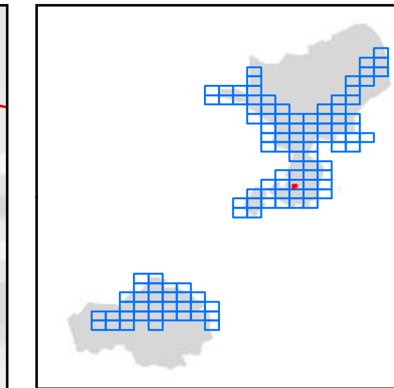


Notes:
1. During final processing, West Yost Associates (WYA) collaborated with the City of Menlo Park on questions regarding water facility configurations. These figures represent areas in which WYA made assumptions greater than the overall assumption of moving the water main to match field verified facilities.



0 4.25 8.5
Scale in Feet

N

Symbology

- Water Meter (5)
- Water Valve, Open (3)
- Backflow Preventer (1)

Processed Water Mains

- Menlo Park, Active
- Menlo Park, Abandoned
- Service Lateral
- Cap Fitting
- Parcels
- Menlo Park District Boundary
- Areas where Configuration was Assumed by WYA

CITY OF MENLO PARK

WEST YOST ASSOCIATES

Assumption 5

Assumptions by WYA during Final Processing

City of Menlo Park
Water System Master Plan

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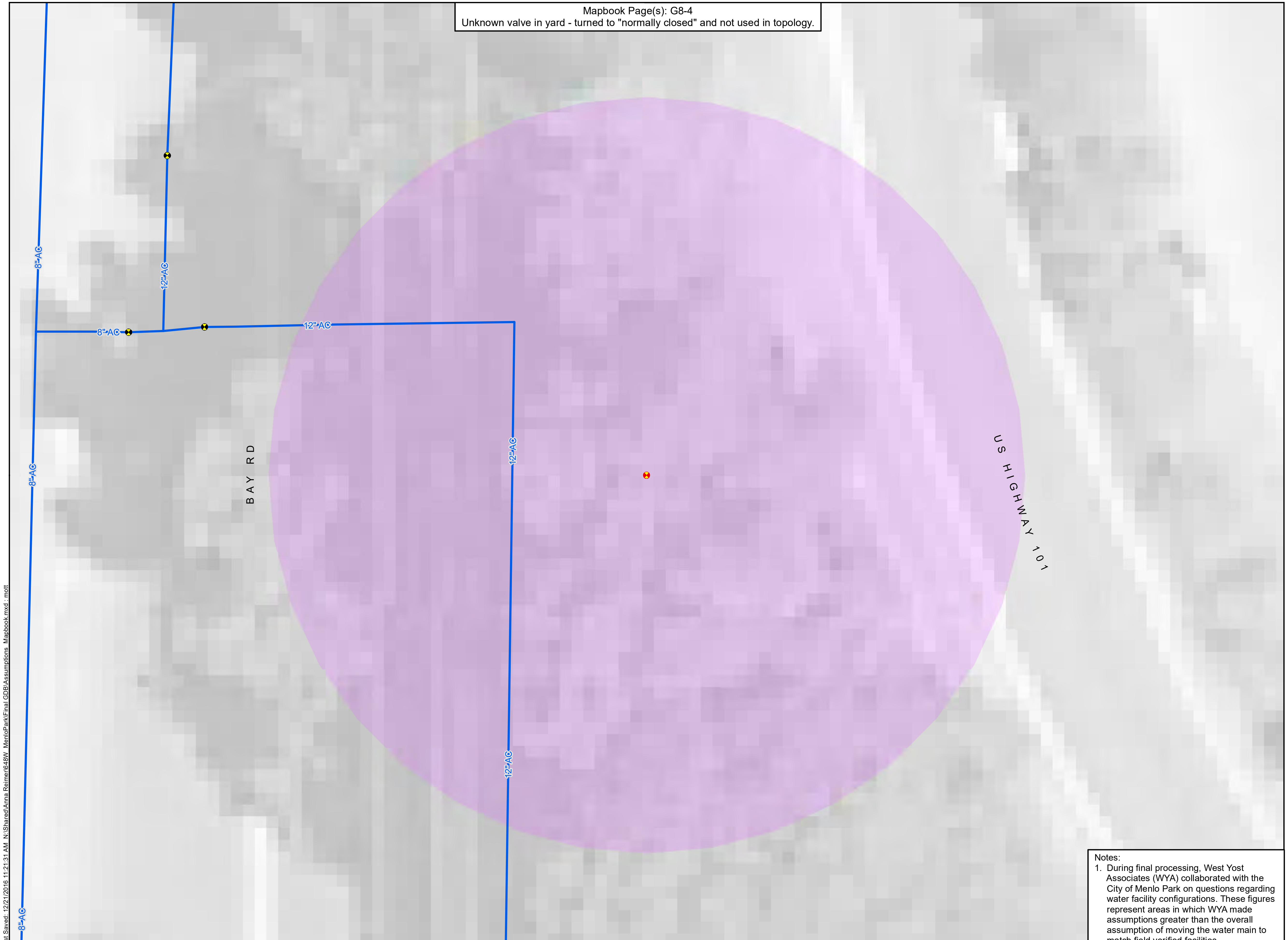
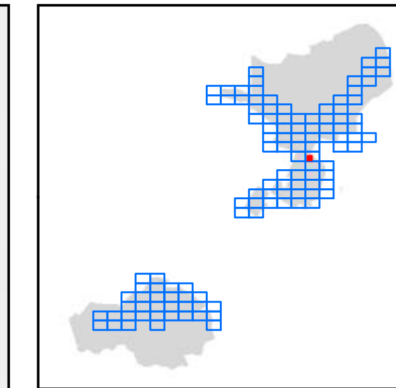


Notes:
1. During final processing, West Yost Associates (WYA) collaborated with the City of Menlo Park on questions regarding water facility configurations. These figures represent areas in which WYA made assumptions greater than the overall assumption of moving the water main to match field verified facilities.



0 3.75 7.5
Scale in Feet

N

Symbology

Water Valve, Open (3)

Water Valve, Closed (1)

Processed Water Mains

Menlo Park, Active

Menlo Park District Boundary

Areas where Configuration was Assumed by WYA

CITY OF MENLO PARK

WEST YOST ASSOCIATES

Assumption 6

Assumptions by WYA during Final Processing

City of Menlo Park
Water System Master Plan

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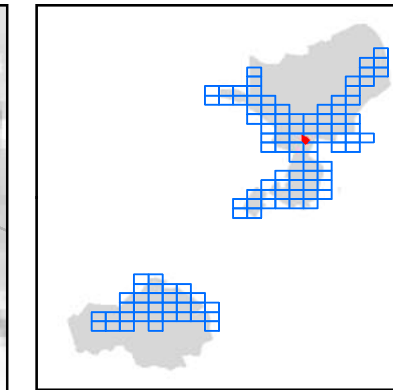
Mapbook Page(s): G7-4
City mark-up places main in South of street, but does not identify where its jog back to the North side of the street occurs. Assumed main jumps to north before Madera.



0 5 10
Scale in Feet

N

Symbology

- Water Meter (7)
- Water Valve, Open (2)
- Fire Hydrant (1)

Processed Water Mains

- Menlo Park, Active
- Hydrant Lateral
- Service Lateral
- Parcels
- Menlo Park District Boundary
- Areas where Configuration was Assumed by WYA

Notes:
1. During final processing, West Yost Associates (WYA) collaborated with the City of Menlo Park on questions regarding water facility configurations. These figures represent areas in which WYA made assumptions greater than the overall assumption of moving the water main to match field verified facilities.

CITY OF MENLO PARK
WEST YOST ASSOCIATES

Assumption 7

Assumptions by WYA during Final Processing

City of Menlo Park
Water System Master Plan

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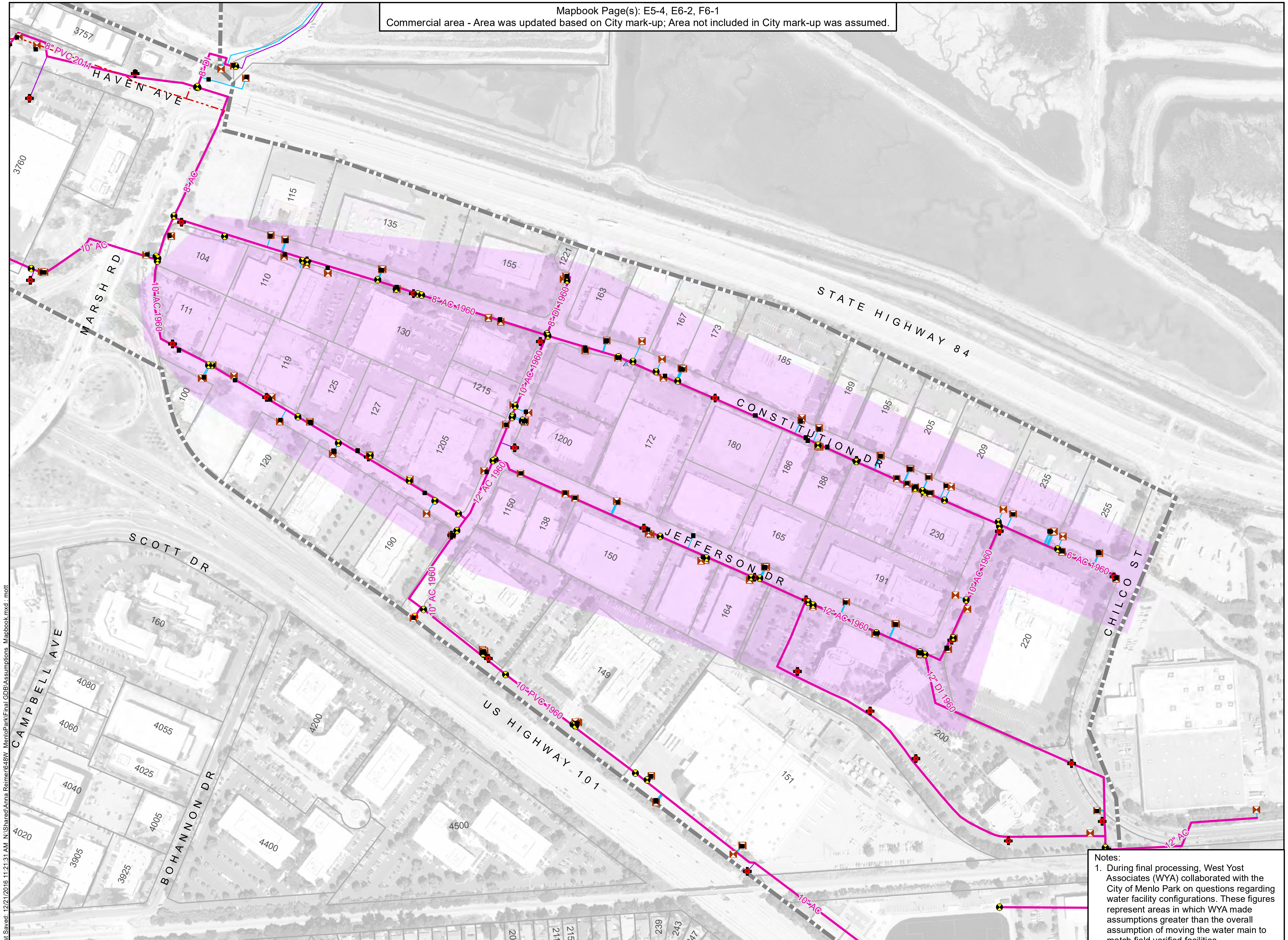
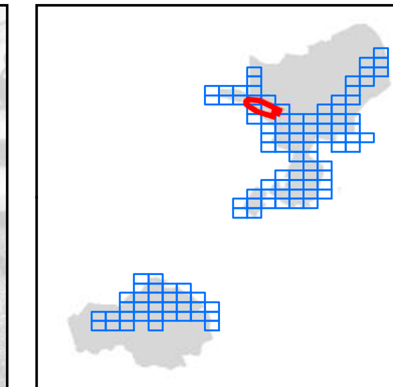
Mapbook Page(s): E5-4, E6-2, F6-1
Commercial area - Area was updated based on City mark-up; Area not included in City mark-up was assumed.





0 155 310
Scale in Feet

N

Symbology

- Water Meter (103)
- Water Valve, Open (74)
- Water Valve, Closed (1)
- Fire Hydrant (30)
- Backflow Preventer (126)

Processed Water Mains

- Menlo Park, Active, High Pressure
- Menlo Park, Abandoned
- Hydrant Lateral
- Service Lateral

City Provided Facilities

- Sampling Station
- Parcels
- Menlo Park District Boundary
- Areas where Configuration was Assumed by WYA

Notes:
1. During final processing, West Yost Associates (WYA) collaborated with the City of Menlo Park on questions regarding water facility configurations. These figures represent areas in which WYA made assumptions greater than the overall assumption of moving the water main to match field verified facilities.

CITY OF MENLO PARK

WEST YOST ASSOCIATES

Assumption 8

Assumptions by WYA during Final Processing

City of Menlo Park
Water System Master Plan

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ATTACHMENT B

Overall Water Facility Geodatabase Structure

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Color Coding:

DOMAIN DEFINED ON SUMMARY TAB
DOMAIN - CODED
DOMAIN - RANGE
SUBTYPE
SUBTYPE-SPECIFIC DOMAIN

Global Domains

DOMAIN - CODED	
Field Type	Text
Split Policy	Default Value
Merge Policy	Default Value
Source	
As-Built	As-Built
Assessor	Assessor
CAD Drawing File	CAD Drawing File
Consultant	Consultant
Engineering	Engineering
Field Work	Field Work
GPS	GPS
Ortho Photo	Ortho Photo
Outside Agency	Outside Agency
Record Map	Record Map

DOMAIN - CODED	
Field Type	Text
Split Policy	Duplicate
Merge Policy	Default Value
WtOwner	
Cal Water	Cal Water
East Palo Alto	East Palo Alto
Menlo Park	Menlo Park
O'Connor	O'Connor
Palo Alto Park Water	Palo Alto Park Water
Private	Private

DOMAIN - CODED	
Field Type	Text
Split Policy	Duplicate
Merge Policy	Default Value
WtMaterial	
AC	AC
CI	CI
CU	CU
FS	FS
DI	DI
DW	DW
ENC	ENC
ERDI	ERDI
HDPE	HDPE
PVC	PVC
STEEL	STEEL
WS	WS

DOMAIN - CODED	
Field Type	Short Integer
Split Policy	Default Value
Merge Policy	Default Value
EnabledDomain	
0	FALSE
1	TRUE

DOMAIN - CODED	
Field Type	Text
Split Policy	Duplicate
Merge Policy	Default Value
WtZone	
Regulated	Regulated
Unregulated	Unregulated

DOMAIN - CODED	
Field Type	Text
Split Policy	Duplicate
Merge Policy	Default Value
Status	
Proposed	Proposed
Active	Active
Abandoned	Abandoned
Removed	Removed

DOMAIN - CODED	
Field Type	Text
Split Policy	Duplicate
Merge Policy	Default Value
YesNo	
Y	Yes
N	No

DOMAIN - CODED	
Field Type	Text
Split Policy	Duplicate
Merge Policy	Default Value
WtServiceArea	
Upper	Upper
Lower	Lower
High Pressure	High Pressure

Easement

Easement								
Field Name	**Field Definition**	**Data Type**	**Allow Nulls**	**Default Value**	**Domain/Subtype**	**Precision**	**Scale**	**Length**
ObjectID	GIS Auto Filled	Object ID	--	--	--	--	--	--
Shape	GIS Auto Filled	Geometry	--	--	--	--	--	--
Shape_Length	GIS Auto Filled	Geometry	--	--	--	--	--	--
Shape_Area	GIS Auto Filled	Geometry	--	--	--	--	--	--
EasementID	Easement ID	Long Integer	Yes			0	--	--
EasementType	Easement type	Text	Yes		EasementType	--	--	50
Grantor	Easement grantor	Text	Yes			--	--	50
Grantee	Easement grantee	Text	Yes			--	--	50
GrantDate	Date easement granted: mm/dd/yyyy	Date	Yes			0	0	0
GrantYear	Year easement granted: yyyy	Long Integer	Yes			0	--	--
ExpirationDate	Date easement expired/s: mm/dd/yyyy	Date	Yes			0	0	0
ExpirationYear	Year easement expired/s: yyyy	Long Integer	Yes			0	--	--
DocumentURL	Hyperlink to easement document	Text	Yes			--	--	255
Notes	Notes regarding easement	Text	Yes			--	--	255
CreateDate	AUTO Date Created: mm/dd/yy	Date	Yes			0	0	0
RevDate	AUTO Date Revised: mm/dd/yyyy	Date	Yes			0	0	0
RevBy	AUTO Revised By	Text	Yes			--	--	50
Remarks	Comments Regarding Revisions	Text	Yes			--	--	254

DOMAIN - CODED	
Field Type	Text
Split Policy	Duplicate
Merge Policy	Default Value
EasementType	
PG&E	PG&E
PUE	PUE
Sewer	Sewer
Storm	Storm
Water	Water
WCE	WCE

WtBackflow

WtBackflow								
Field Name	**Field Definition**	**Data Type**	**Allow Nulls**	**Default Value**	**Domain/Subtype**	**Precision**	**Scale**	**Length**
ObjectID	GIS Auto Filled	Object ID	--	--	--	--	--	--
Shape	GIS Auto Filled	Geometry	--	--	--	--	--	--
FacilityID	Backflow ID	Text	Yes			--	--	16
BackflowType	Backflow Type	Text	Yes		WtBackflowType	--	--	50
ModelNumber	Model Number	Text	Yes			--	--	20
MeterID	Meter ID	Long Integer	Yes			0	--	--
BarrelDiameter	Barrel Diameter	Double	Yes		WtBackflowDiameter	0	0	--
BypassDiameter	Bypass Diameter	Double	Yes		WtBypassDiameter	0	0	--
IsLocked	Locked?	Text	Yes		YesNo	--	--	1
SprinklerUse	Used for FIRE service sprinklers?	Text	Yes		YesNo	--	--	1
Elevation	Elevation of Backflow	Double	Yes			0	0	--
ServiceArea	Location within City Limits	Text	Yes		WtServiceArea	--	--	50
PressureZone	Pressure Zone	Text	Yes		WtZone	--	--	20
Location	Location of backflow	Text	Yes			--	--	50
StreetName	Street backflow is on	Text	Yes			--	--	50
CastingYear	Casting Year: yyyy	Long Integer	Yes			0	--	--
DateofLastService	Date of Last Service: mm/dd/yyyy	Date	Yes			0	0	0
Owner	Backflow Owner	Text	Yes		WtOwner	--	--	50
Manufacturer	Backflow Manufacturer	Text	Yes		WtBackflowCompany	--	--	50
LifeCycleStatus	Backflow Life Cycle Status	Text	Yes		Status	--	--	10
SourceType	Sourcetype of backflow data	Text	Yes		Source	--	--	50
SourceName	Sourcename of backflow data	Text	Yes			--	--	50
CreateDate	AUTO Date Created: mm/dd/yy	Date	Yes			0	0	0
RevDate	AUTO Date Revised: mm/dd/yyyy	Date	Yes			0	0	0
RevBy	AUTO Revised By	Text	Yes			--	--	50
Remarks	Comments Regarding Revisions	Text	Yes			--	--	254
Enabled	Enabled or not	Short Integer	Yes	TRUE	EnabledDomain	0	--	--

DOMAIN - CODED	
Field Type	Text
Split Policy	Duplicate
Merge Policy	Default Value
WtBackflowCompany	
Ames	Ames
Apollo	Apollo
Central	Central
FEBCO	FEBCO
Hersey	Hersey
Jefferson	Jefferson
SMR	SMR
Watts	Watts
Wilkins-Zurn	Wilkins-Zurn

DOMAIN - CODED	
Field Type	Double
Split Policy	Duplicate
Merge Policy	Default Value
WtBypassDiameter	
0.33	1/3"
0.5	1/2"
0.63	5/8"
0.75	3/4"
1	1"
1.25	1-1/4"
1.5	1-1/2"
2	2"
3.25	3-1/4"

DOMAIN - CODED	
Field Type	Double
Split Policy	Duplicate
Merge Policy	Default Value
WtBackflowDiameter	
0.63	5/8"
0.75	3/4"
1	1"
1.25	1-1/4"
1.5	1-1/2"
2	2"
2.5	2-1/2"
3	3"
3.25	3-1/4"
4	4"
5	5"
6	6"
8	8"
10	10"

DOMAIN - CODED	
Field Type	Text
Split Policy	Duplicate
Merge Policy	Default Value
WtBackflowType	
DCA with Reverse Pressure Zone	DCA with Reverse Pressure Zone
Double Check Assembly	Double Check Assembly

WtControlValve

WtControlValve								
Field Name	Field Definition	Data Type	Allow Nulls	Default Value	Domain/Subtype	Precision	Scale	Length
ObjectID	GIS Auto Filled	Object ID	--	--	--	--	--	--
Shape	GIS Auto Filled	Geometry	--	--	--	--	--	--
FacilityID	Valve ID	Text	Yes			--	--	16
ValveType	Valve type	Short Integer	Yes	99-Unspecified	SubType	0	--	--
IsOperable	Yes or no is operable	Text	Yes		YesNo	--	--	1
Diameter	Diameter	Double	Yes		WtValveDiameter	0	0	--
Material	Material	Text	Yes		WtMaterial	--	--	10
Elevation	Ground Surface Elevation of Hydrant	Double	Yes			0	0	--
ServiceArea	Location within City Limits	Text	Yes		WtServiceArea	0	0	50
PressureZone	Pressure Zone	Text	Yes		WtZone	--	--	20
Location	Location of valve	Text	Yes			--	--	50
StreetName	StreetName of valve	Text	Yes			--	--	50
InstallDate	Installation Date: mm/dd/yyyy	Date	Yes			0	0	0
InstallYear	Installation Year: yyyy	Long Integer	Yes			0	--	--
DateofLastService	Date of Last Service: mm/dd/yyyy	Date	Yes			0	0	0
Owner	Owner	Text	Yes		WtOwner	--	--	50
LifeCycleStatus	Life Cycle Status	Text	Yes		Status	--	--	10
SourceType	Sourcetype of valve data	Text	Yes		Source	--	--	50
SourceName	Sourcename of valve data	Text	Yes			--	--	50
SymRotation	Rotation value for the valve symbol	Double	Yes			0	0	--
CreateDate	AUTO Date Created: mm/dd/yy	Date	Yes			0	0	0
RevDate	AUTO Date Revised: mm/dd/yyyy	Date	Yes			0	0	0
RevBy	AUTO Revised By	Text	Yes			--	--	50
Remarks	Comments Regarding Revisions	Text	Yes			--	--	254
FieldVerified	The valve has been field verified?	Text	Yes		YesNo	--	--	1
Enabled	Enabled or not	Short Integer	Yes	TRUE	EnabledDomain	0	--	--

SUBTYPE	
Field Type	Short Integer
Field Name	ValveType
SubType	
1	Air Release
2	Blow-Off
3	Pressure Reducing
4	Intertie
5	Turnout
99	Unspecified

DOMAIN - CODED	
Field Type	Double
Split Policy	Duplicate
Merge Policy	Default Value
WtValveDiameter	
1	1"
2	2"
3	3"
4	4"
6	6"
8	8"
10	10"
12	12"
14	14"
16	16"
18	18"

WtDistrictBoundary

WtDistrictBoundary								
Field Name	**Field Definition**	**Data Type**	**Allow Nulls**	**Default Value**	**Domain/Subtype**	**Precision**	**Scale**	**Length**
ObjectID	GIS Auto Filled	Object ID	--	--	--	--	--	--
Shape	GIS Auto Filled	Geometry	--	--	--	--	--	--
Shape_Length	GIS Auto Filled	Geometry	--	--	--	--	--	--
Shape_Area	GIS Auto Filled	Geometry	--	--	--	--	--	--
DistrictName	District Name	Text	Yes			--	--	--
ServiceArea	Location within City Limits	Text	Yes		WtServiceArea	--	--	50
PressureZone	Pressure Zone	Text	Yes		WtZone	--	--	20
SourceType	sourcetype of district boundary	Text	Yes		Source	--	--	50
SourceName	sourcename of sourcetype	Text	Yes			--	--	50
CreateDate	AUTO Date Created: mm/dd/yy	Date	Yes			0	0	0
RevDate	AUTO Date Revised: mm/dd/yyyy	Date	Yes			0	0	0
RevBy	AUTO Revised By	Text	Yes			--	--	50
Remarks	Comments Regarding Revisions	Text	Yes			--	--	254

WtFacility

WtFacility								
Field Name	**Field Definition**	**Data Type**	**Allow Nulls**	**Default Value**	**Domain/Subtype**	**Precision**	**Scale**	**Length**
ObjectID	GIS Auto Filled	Object ID	--	--	--	--	--	--
Shape	GIS Auto Filled	Geometry	--	--	--	--	--	--
FacilityID	Facility ID	Text	Yes			--	--	16
FacilityName	Facility name	Text	Yes			--	--	50
FacilityType	Facility type	Short Integer	Yes	99-Unspecified	SubType	0	--	--
FacilitySubType	Facility Subtype	Text	Yes		SubT1-WtTankType SubT2-WtWellType SubT3-WtPumpType	--	--	50
ServiceArea	Location within City Limits	Text	Yes		WtServiceArea	--	--	50
PressureZone	Pressure Zone	Text	Yes		WtZone	--	--	20
Location	Location of facility	Text	Yes			--	--	50
StreetName	StreetName of facility	Text	Yes			--	--	50
InstallDate	Installation Date: mm/dd/yyyy	Date	Yes			0	0	0
InstallYear	Installation Year: yyyy	Long Integer	Yes			0	--	--
Owner	Owner	Text	Yes		WtOwner	--	--	50
LifeCycleStatus	Life Cycle Status	Text	Yes		Status	--	--	10
SourceType	Sourcetype of facility data	Text	Yes		Source	--	--	50
SourceName	Sourcename of facility data	Text	Yes			--	--	50
SymRotation	Rotation value for the facility symbol	Double	Yes			0	0	--
CreateDate	AUTO Date Created: mm/dd/yy	Date	Yes			0	0	0
RevDate	AUTO Date Revised: mm/dd/yyyy	Date	Yes			0	0	0
RevBy	AUTO Revised By	Text	Yes			--	--	50
Remarks	Comments Regarding Revisions	Text	Yes			--	--	254
Enabled	Enabled or not	Short Integer	Yes	TRUE	EnabledDomain	0	--	--
AncillaryRole	Ancillary role for additional use	Short Integer	Yes		AncillaryRoleDomain	0	--	--

SUBTYPE	
Field Type	Short Integer
Field Name	FacilityType
SubType	
1	Water Tank
2	Well
3	Pump Station
4	Storage Basin
5	Treatment Plant
99	Unspecified

DOMAIN - CODED	
Field Type	Short Integer
Split Policy	Default Value
Merge Policy	Default Value
AncillaryRoleDomain	
0	None
1	Source
2	Sink

DOMAIN - CODED	
Field Type	Text
Split Policy	Default Value
Merge Policy	Default Value
WtWellType	
Water Supply Well	Water Supply Well
Injection Well	Injection Well
ASR Well	ASR Well
Blending Well	Blending Well
Backup Well	Backup Well
Monitoring Well	Monitoring Well

DOMAIN - CODED	
Field Type	Text
Split Policy	Default Value
Merge Policy	Default Value
WtPumpType	
In-Line Pump	In-Line Pump
Recirculation Pump	Recirculation Pump
Storage Pump	Storage Pump
Supply Pump	Supply Pump

DOMAIN - CODED	
Field Type	Text
Split Policy	Default Value
Merge Policy	Default Value
WtTankType	
At Grade Tank	At Grade Tank
Elevated Tank	Elevated Tank
Gravity Tank	Gravity Tank

WtFitting

WtFitting								
Field Name	**Field Definition**	**Data Type**	**Allow Nulls**	**Default Value**	**Domain/Subtype**	**Precision**	**Scale**	**Length**
ObjectID	GIS Auto Filled	Object ID	--	--	--	--	--	--
Shape	GIS Auto Filled	Geometry	--	--	--	--	--	--
FacilityID	Fitting ID	Text	Yes			--	--	16
FittingType	Fitting Type	Short Integer	Yes	99-Unspecified	SubType	0	--	--
Diameter	Diameter	Double	Yes		WtFittingDiameter	0	0	--
Material	Material	Text	Yes		WtMaterial	--	--	10
ServiceArea	Location within City Limits	Text	Yes		WtServiceArea	--	--	50
PressureZone	Pressure Zone	Text	Yes		WtZone	--	--	20
Location	Location of fitting	Text	Yes			--	--	50
StreetName	StreetName of fitting	Text	Yes			--	--	50
InstallDate	Installation Date: mm/dd/yyyy	Date	Yes			0	0	0
InstallYear	Installation Year: yyyy	Long Integer	Yes			0	--	--
Owner	Owner	Text	Yes		WtOwner	--	--	50
LifeCycleStatus	Life Cycle Status	Text	Yes		Status	--	--	10
SourceType	Sourcetype of fitting data	Text	Yes		Source	--	--	50
SourceName	Sourcename of fitting data	Text	Yes			--	--	50
SymRotation	Rotation value for the fitting symbol	Double	Yes			0	0	--
CreateDate	AUTO Date Created: mm/dd/yy	Date	Yes			0	0	0
RevDate	AUTO Date Revised: mm/dd/yyyy	Date	Yes			0	0	0
RevBy	AUTO Revised By	Text	Yes			--	--	50
Remarks	Comments Regarding Revisions	Text	Yes			--	--	254
Enabled	Enabled or not	Short Integer	Yes	TRUE	EnabledDomain	0	--	--

SUBTYPE	
Field Type	Short Integer
Field Name	FittingType
SubType	
1	Cap
2	Cross
3	Coupling
4	Flange
5	Joint
6	Tee
99	Unspecified

DOMAIN - CODED	
Field Type	Double
Split Policy	Duplicate
Merge Policy	Default Value
WtFittingDiameter	
1	1"
2	2"
3	3"
4	4"
6	6"
8	8"
10	10"
12	12"
14	14"
16	16"
18	18"

WtHydrant

WtHydrant								
Field Name	**Field Definition**	**Data Type**	**Allow Nulls**	**Default Value**	**Domain/Subtype**	**Precision**	**Scale**	**Length**
ObjectID	GIS Auto Filled	Object ID	--	--	--	--	--	--
Shape	GIS Auto Filled	Geometry	--	--	--	--	--	--
FacilityID	Hydrant or Facility ID	Text	Yes			--	--	16
BarrelDiameter	Diameter of the barrel	Double	Yes		WtHydrantDiameter	0	0	--
BarrelType	Wet or dry barrel	Text	Yes		WtHydrantType	--	--	5
NmbrNozTotal	Total Number of Nozzles	Short Integer	Yes		WtHydrantPorts	0	--	--
NmbrNoz25	Total Number of 2.5" nozzles	Short Integer	Yes			0	--	--
NmbrNoz40	Total Number of 4.0" nozzles	Short Integer	Yes			0	--	--
NmbrNoz45	Total Number of 4.5" nozzles	Short Integer	Yes			0	--	--
Elevation	Ground Surface Elevation of Hydrant	Double	Yes			0	0	--
GPM	GPM of the Hydrant	Short Integer	Yes		WtHydrantGPM	0	--	--
StaticPressure	Static pressure	Double	Yes			0	0	--
ResidualPressure	Residual pressure	Double	Yes			0	0	--
ServiceArea	Location within City Limits	Text	Yes		WtServiceArea	--	--	50
PressureZone	Pressure Zone	Text	Yes		WtZone	--	--	20
Location	Locatoin of hydrant	Text	Yes			--	--	50
StreetName	Street hydrant is on	Text	Yes			--	--	50
InstallYear	Install Year: yyyy	Long Integer	Yes			0	--	--
CastingYear	Casting Year: yyyy	Long Integer	Yes			0	--	--
DateofLastService	Date of Last Service: mm/dd/yyyy	Date	Yes			0	0	0
Owner	Hydrant Owner	Text	Yes		WtOwner	--	--	50
IsPrivate	Yes or no is private	Text	Yes		YesNo	--	--	1
Manufacturer	Hydrant Manufacturer	Text	Yes		WtHydrantCompany	--	--	50
LifeCycleStatus	Hydrant Life Cycle Status	Text	Yes		Status	--	--	10
SourceType	Sourcetype of hydrant data	Text	Yes		Source	--	--	50
SourceName	Sourcename of hydrant data	Text	Yes			--	--	50
CreateDate	AUTO Date Created: mm/dd/yy	Date	Yes			0	0	0
RevDate	AUTO Date Revised: mm/dd/yyyy	Date	Yes			0	0	0
RevBy	AUTO Revised By	Text	Yes			--	--	50
Remarks	Comments Regarding Revisions	Text	Yes			--	--	254
Enabled	Enabled or not	Short Integer	Yes	TRUE	EnabledDomain	0	--	--

DOMAIN - CODED	
Field Type	Text
Split Policy	Duplicate
Merge Policy	Default Value
WtHydrantCompany	
Clow	Clow
Greenberg	Greenberg
Iowa	Iowa
Mueller	Mueller
PSCIP	PSCIP
Rensselaer	Rensselaer
Rich	Rich

DOMAIN - CODED	
Field Type	Text
Split Policy	Duplicate
Merge Policy	Default Value
WtHydrantType	
Wet	Wet
Dry	Dry

DOMAIN - RANGE	
Field Type	Short Integer
Split Policy	Duplicate
Merge Policy	Default Value
WtHydrantGPM	
0 - 4000	

DOMAIN - RANGE	
Field Type	Short Integer
Split Policy	Duplicate
Merge Policy	Default Value
WtHydrantPorts	
1 - 4	

DOMAIN - CODED	
Field Type	Double
Split Policy	Duplicate
Merge Policy	Default Value
WtHydrantDiameter	
4	4"
5	5"
5.25	5-1/4"

WtLateral

WtLateral								
Field Name	**Field Definition**	**Data Type**	**Allow Nulls**	**Default Value**	**Domain/Subtype**	**Precision**	**Scale**	**Length**
ObjectID	GIS Auto Filled	Object ID	--	--	--	--	--	--
Shape	GIS Auto Filled	Geometry	--	--	--	--	--	--
Shape_Length	GIS Auto Filled	Geometry	--	--	--	--	--	--
FacilityID	Pipe or Facility ID	Text	Yes			--	--	16
LateralType	Lateral type: service or hydrant	Short Integer	Yes	1-HydrantLateral	SubType	0	--	--
LateralSubType	Lateral subtype if service lateral	Text	Yes		SubT2-WtLateralType	--	--	5
Diameter	Diameter	Double	Yes		SubT1-WtHydrantLateralDiameter SubT2-WtServiceLateralDiameter	0	0	--
Material	Material	Text	Yes		WtMaterial	--	--	10
LengthReported	Length reported from Source	Double	Yes			0	0	--
IsHighPressure	Is the pipe high pressure?	Text	Yes		YesNo	--	--	1
ServiceArea	Location within City Limits	Text	Yes		WtServiceArea	--	--	50
PressureZone	Pressure Zone	Text	Yes		WtZone	--	--	20
Location	location of pipeline	Text	Yes			--	--	50
StreetName	streetname of pipeline	Text	Yes			--	--	50
InstallDate	Pipe Installation Date: mm/dd/yyyy	Date	Yes			0	0	0
InstallYear	Pipe Installation Year: yyyy	Long Integer	Yes			0	--	--
Owner	Pipe Owner	Text	Yes		WtOwner	--	--	50
LifeCycleStatus	Pipe Life Cycle Status	Text	Yes		Status	--	--	10
SourceType	sourcetype of pipeline	Text	Yes		Source	--	--	50
SourceName	sourcename of pipeline	Text	Yes			--	--	50
CreateDate	AUTO Date Created: mm/dd/yy	Date	Yes			0	0	0
RevDate	AUTO Date Revised: mm/dd/yyyy	Date	Yes			0	0	0
RevBy	AUTO Revised By	Text	Yes			--	--	50
Remarks	Comments Regarding Revisions	Text	Yes			--	--	254
Enabled	Enabled or not	Short Integer	Yes	TRUE	EnabledDomain	0	--	--

SUBTYPE	
Field Type	Short Integer
Field Name	LateralType
SubType	
1	Hydrant Lateral
2	Service Lateral

DOMAIN - CODED	
Field Type	Double
Split Policy	Duplicate
Merge Policy	Default Value
WtHydrantLateralDiameter	
4	4"
6	6"
8	8"

DOMAIN - CODED	
Field Type	Text
Split Policy	Default Value
Merge Policy	Default Value
WtLateralType	
FS	Fire Service
CS	Commercial Service
DS	Domestic Service
IS	Irrigation Service

DOMAIN - CODED	
Field Type	Double
Split Policy	Duplicate
Merge Policy	Default Value
WtServiceLateralDiameter	
0.75	3/4"
1	1"
1.5	1-1/2"
2	2"
3	3"
4	4"
6	6"
8	8"

WtMain

WtMain								
Field Name	**Field Definition**	**Data Type**	**Allow Nulls**	**Default Value**	**Domain/Subtype**	**Precision**	**Scale**	**Length**
ObjectID	GIS Auto Filled	Object ID	--	--	--	--	--	--
Shape	GIS Auto Filled	Geometry	--	--	--	--	--	--
Shape_Length	GIS Auto Filled	Geometry	--	--	--	--	--	--
FacilityID	Pipe or Facility ID	Text	Yes			--	--	16
Diameter	Diameter	Double	Yes		WtMainDiameter	0	0	--
Material	Material	Text	Yes		WtMaterial	--	--	10
MaterialSubclass	Material Subclass	Text	Yes		WtMaterialSubclass	--	--	10
LengthReported	Length reported from Source	Double	Yes			0	0	--
IsHighPressure	Is the pipe high pressure?	Text	Yes		YesNo	--	--	1
ServiceArea	Location within City Limits	Text	Yes		WtServiceArea	--	--	50
PressureZone	Pressure Zone	Text	Yes		WtZone	--	--	20
Location	location of pipeline	Text	Yes			--	--	50
StreetName	streetname of pipeline	Text	Yes			--	--	50
InstallDate	Pipe Installation Date: mm/dd/yyyy	Date	Yes			0	0	0
InstallYear	Pipe Installation Year: yyyy	Long Integer	Yes			0	--	--
InstallType	Pipe lining installation type	Text	Yes		WtMainLining	--	--	50
Owner	Pipe Owner	Text	Yes		WtOwner	--	--	50
LifeCycleStatus	Pipe Life Cycle Status	Text	Yes		Status	--	--	10
SourceType	sourcetype of pipeline	Text	Yes		Source	--	--	50
SourceName	sourcename of pipeline	Text	Yes			--	--	50
CreateDate	AUTO Date Created: mm/dd/yy	Date	Yes			0	0	0
RevDate	AUTO Date Revised: mm/dd/yyyy	Date	Yes			0	0	0
RevBy	AUTO Revised By	Text	Yes			--	--	50
Remarks	Comments Regarding Revisions	Text	Yes			--	--	254
Enabled	Enabled or not	Short Integer	Yes	TRUE	EnabledDomain	0	--	--

DOMAIN - CODED	
Field Type	Double
Split Policy	Duplicate
Merge Policy	Default Value
WtMainDiameter	
1	1"
2	2"
3	3"
4	4"
6	6"
8	8"
10	10"
12	12"
14	14"
16	16"
18	18"

DOMAIN - CODED	
Field Type	Text
Split Policy	Duplicate
Merge Policy	Default Value
WtMaterialSubclass	
C900	C900
C909	C909

DOMAIN - CODED	
Field Type	Text
Split Policy	Duplicate
Merge Policy	Default Value
WtMainLining	
Constructed Cured in Place	Constructed Cured in Place
Constructed Fold and Form	Constructed Fold and Form
Repaired Cure in Place	Repaired Cure in Place
Repaired Fold and Form	Repaired Fold and Form

WtMeter

WtMeter								
Field Name	**Field Definition**	**Data Type**	**Allow Nulls**	**Default Value**	**Domain/Subtype**	**Precision**	**Scale**	**Length**
ObjectID	GIS Auto Filled	Object ID	--	--	--	--	--	--
Shape	GIS Auto Filled	Geometry	--	--	--	--	--	--
FacilityID	Meter ID	Text	Yes			--	--	16
AccountID	Account ID	Text	Yes			--	--	50
AddressID	Address number only	Long Integer	Yes			0	--	--
Diameter	Diameter	Double	Yes		WtMeterDiameter	0	0	--
BoxType	Shape of meter box	Text	Yes		WtMeterBoxType	--	--	20
BoxCondition	Condition of meter box	Text	Yes		WtMeterBoxCondition	--	--	10
MeterType	Meter type	Text	Yes		WtMeterType	--	--	20
MeterModel	Meter model	Text	Yes		WtMeterModel	--	--	20
MeterNumber	Meter number	Double	Yes			0	0	--
ServiceArea	Location within City Limits	Text	Yes		WtServiceArea	--	--	50
PressureZone	Pressure Zone	Text	Yes		WtZone	--	--	20
Location	Location of meter	Text	Yes			--	--	50
StreetName	Streetname of meter	Text	Yes			--	--	50
InstallDate	Installation Date: mm/dd/yyyy	Date	Yes			0	0	10
InstallYear	Installation Year: yyyy	Long Integer	Yes			0	--	--
Owner	Owner	Text	Yes		WtOwner	--	--	50
Manufacturer	Manufacturer	Text	Yes		WtMeterCompany	--	--	50
Elevation	Ground Surface Elevation of meter	Double	Yes			0	0	--
LifeCycleStatus	Meter Life Cycle Status	Text	Yes		Status	--	--	10
SourceType	Sourcetype of valve data	Text	Yes		Source	--	--	50
SourceName	Sourcename of valve data	Text	Yes			--	--	50
SymRotation	Rotation value for the valve symbol	Double	Yes			0	0	--
CreateDate	AUTO Date Created: mm/dd/yy	Date	Yes			0	0	0
RevDate	AUTO Date Revised: mm/dd/yyyy	Date	Yes			0	0	0
RevBy	AUTO Revised By	Text	Yes			--	--	50
Remarks	Comments Regarding Revisions	Text	Yes			--	--	254
FieldVerified	Yes or no the valve has been field verified	Text	Yes		YesNo	--	--	1
Enabled	Enabled or not	Short Integer	Yes	TRUE	EnabledDomain	0	--	--

DOMAIN - CODED	
Field Type	Text
Split Policy	Duplicate
Merge Policy	Default Value
WtMeterCompany	
Arad	Arad
Badger	Badger
Hersey	Hersey
Kent	Kent
Master Meter	Master Meter
Neptune	Neptune
Rockwell	Rockwell
Sensus	Sensus

DOMAIN - CODED	
Field Type	Double
Split Policy	Duplicate
Merge Policy	Default Value
WtMeterDiameter	
0.63	5/8"
0.75	3/4"
1	1"
1.5	1.5"
2	2"
3	3"
4	4"
6	6"

DOMAIN - CODED	
Field Type	Text
Split Policy	Duplicate
Merge Policy	Default Value
WtMeterModel	
C2	C2
Compound	Compound
OMNI	OMNI
S/II	S/II
S-3	S-3
SR1	SR1
SR2	SR2
W-1000	W-1000
W-120	W-120
W-120/W-160	W-120/W-160
W-160	W-160
W-19	W-19
W-350	W-350
W-3500	W-3500
Y-10	Y-10
Z-14	Z-14

DOMAIN - CODED	
Field Type	Text
Split Policy	Duplicate
Merge Policy	Default Value
WtMeterType	
Direct Dial	Direct Dial
Touch Read	Touch Read

DOMAIN - CODED	
Field Type	Text
Split Policy	Duplicate
Merge Policy	Default Value
WtMeterBoxCondition	
Dirty	Dirty
Clean	Clean

DOMAIN - CODED	
Field Type	Text
Split Policy	Duplicate
Merge Policy	Default Value
WtMeterBoxType	
Rectangular	Rectangular
Round	Round

WtSamplingStation

WtSamplingStation								
Field Name	**Field Definition**	**Data Type**	**Allow Nulls**	**Default Value**	**Domain/Subtype**	**Precision**	**Scale**	**Length**
ObjectID	GIS Auto Filled	Object ID	--	--	--	--	--	--
Shape	GIS Auto Filled	Geometry	--	--	--	--	--	--
FacilityID	Sampling station ID	Text	Yes			--	--	16
StationType	Station Type	Short Integer	Yes	99-Unspecified	SubType	0	--	--
Pedestal	yes or no pedestal	Text	Yes		YesNo	--	--	1
ServiceArea	Location within City Limits	Text	Yes		WtServiceArea	--	--	50
PressureZone	Pressure Zone	Text	Yes		WtZone	--	--	20
Location	Location of station	Text	Yes			--	--	50
StreetName	StreetName of station	Text	Yes			--	--	50
InstallDate	Installation Date: mm/dd/yyyy	Date	Yes			0	0	0
InstallYear	Installation Year: yyyy	Long Integer	Yes			0	--	--
Owner	Owner	Text	Yes		WtOwner	--	--	50
LifeCycleStatus	Life Cycle Status	Text	Yes		Status	--	--	10
SourceType	Sourcetype of station data	Text	Yes		Source	--	--	50
SourceName	Sourcename of station data	Text	Yes			--	--	50
SymRotation	Rotation value for the station symbol	Double	Yes			0	0	--
CreateDate	AUTO Date Created: mm/dd/yy	Date	Yes			0	0	0
RevDate	AUTO Date Revised: mm/dd/yyyy	Date	Yes			0	0	0
RevBy	AUTO Revised By	Text	Yes			--	--	50
Remarks	Comments Regarding Revisions	Text	Yes			--	--	254
Enabled	Enabled or not	Short Integer	Yes	TRUE	EnabledDomain	0	--	--

SUBTYPE	
Field Type	Short Integer
Field Name	FittingType
SubType	
1	Round
2	Square
99	Unspecified

WtSystemValve

WtSystemValve								
Field Name	**Field Definition**	**Data Type**	**Allow Nulls**	**Default Value**	**Domain/Subtype**	**Precision**	**Scale**	**Length**
ObjectID	GIS Auto Filled	Object ID	--	--	--	--	--	--
Shape	GIS Auto Filled	Geometry	--	--	--	--	--	--
FacilityID	Valve ID	Text	Yes			--	--	16
ValveType	Valve type	Short Integer	Yes	99-Unspecified	SubType	0	--	--
IsZoneValve	Yes or no is zone valve	Text	Yes		YesNo	--	--	1
IsBypassValve	Yes or no is bypass valve	Text	Yes		YesNo	--	--	1
IsOperable	Yes or no is operable	Text	Yes		YesNo	--	--	1
IsNormallyOpen	Yes or no is normally open	Text	Yes		YesNo	--	--	1
NumberTurnsToClose	Number of turns to close the valve	Short Integer	Yes			0	--	--
ClockwiseToClose	Yes or no turns clockwise to close	Text	Yes		YesNo	--	--	1
Diameter	Diameter	Double	Yes		WtValveDiameter	0	0	--
Material	Material	Text	Yes		WtMaterial	--	--	10
Elevation	Ground Surface Elevation of Hydrant	Double	Yes			0	0	--
ServiceArea	Location within City Limits	Text	Yes		WtServiceArea	0	0	50
PressureZone	Pressure Zone	Text	Yes		WtZone	--	--	20
Location	Location of valve	Text	Yes			--	--	50
StreetName	StreetName of valve	Text	Yes			--	--	50
InstallDate	Installation Date: mm/dd/yyyy	Date	Yes			0	0	0
InstallYear	Installation Year: yyyy	Long Integer	Yes			0	--	--
DateofLastService	Date of Last Service: mm/dd/yyyy	Date	Yes			0	0	0
Owner	Owner	Text	Yes		WtOwner	--	--	50
LifeCycleStatus	Life Cycle Status	Text	Yes		Status	--	--	10
SourceType	Sourcetype of valve data	Text	Yes		Source	--	--	50
SourceName	Sourcename of valve data	Text	Yes			--	--	50
SymRotation	Rotation value for the valve symbol	Double	Yes			0	0	--
CreateDate	AUTO Date Created: mm/dd/yy	Date	Yes			0	0	0
RevDate	AUTO Date Revised: mm/dd/yyyy	Date	Yes			0	0	0
RevBy	AUTO Revised By	Text	Yes			--	--	50
Remarks	Comments Regarding Revisions	Text	Yes			--	--	254
FieldVerified	The valve has been field verified?	Text	Yes		YesNo	--	--	1
Enabled	Enabled or not	Short Integer	Yes	TRUE	EnabledDomain	0	--	--

SUBTYPE	
Field Type	Short Integer
Field Name	ValveType
SubType	
1	Gate
2	Butterfly
99	Unspecified

DOMAIN - CODED	
Field Type	Double
Split Policy	Duplicate
Merge Policy	Default Value
WtValveDiameter (shared with WtControlValve)	
1	1"
2	2"
3	3"
4	4"
6	6"
8	8"
10	10"
12	12"
14	14"
16	16"
18	18"

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APPENDIX B

Hydrant Testing for Model Calibration

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WEST YOST ASSOCIATES
Consulting Engineers

MEMORANDUM

DATE: October 5, 2016 Project No.: 648-12-15-01
SENT VIA: EMAIL

TO: Azalea Mitch, City of Menlo Park

FROM: Roberto Vera, PE, RCE #83500

REVIEWED BY: Polly Boissevain, PE, RCE #36164

SUBJECT: Menlo Park Municipal Utilities District – Water System Master Plan
Hydrant Testing for Hydraulic Model Calibration

This memorandum summarizes the proposed hydrant tests and testing procedures required to calibrate the hydraulic model of Menlo Park Municipal Water District's (MPMWD) existing water distribution system. This work is being conducted as part of the Water System Master Plan project, and provides a plan for the collection of the necessary field data. West Yost Associates' (West Yost) recommended program for hydrant testing is summarized below and provided for your review and comment.

HYDRANT TESTING PROGRAM

The hydrant testing program will be used to confirm and "spot-check" the roughness factors (C-factors) that are assigned to pipelines in MPMWD's hydraulic model. West Yost will use data collected directly through hydrant testing to verify if the current pipeline C-factors assigned in the MPMWD's hydraulic model are appropriate. Depending on this field testing to determine representative C-factors by pipeline material type and pipeline age, pipeline C-factors may be adjusted in the hydraulic model to better reflect field conditions.

Details related to the hydrant testing program are divided into the following four separate categories and are discussed in more detail below:

- Personnel and System Data Requirements
- Hydrant Testing Schedule
- Testing Requirements and Procedure
- MPMWD Responsibilities

Personnel and System Data Requirements

West Yost would like to request the following MPMWD personnel, system data, and supporting documents to accomplish the recommended hydrant testing program under West Yost's direction:

- A minimum of three MPMWD staff members (with vehicles and radio communications) that will be available during regular working hours to assist with, but not limited to, the following:
  - Closing and re-opening valves, as needed before and after hydrant testing,
  - Reading and recording hydrant pressure data,
  - De-chlorination at the flowing test hydrant,
  - Flowing the test hydrant,
  - Directing and controlling traffic, and hydrant flows, as necessary, to ensure safety during these hydrant flow tests, and collect this discharged water into a vac truck during each test, and
  - Public outreach and interface, as necessary.
- System information before and during the hydrant testing period that includes the following:
  - MPMWD's SCADA system information for:
    - Turnout flow from San Francisco Public Utilities Commission (SFPUC) turnouts[1]
    - Pressure downstream of valves at SFPUC turnouts
    - Sand Hill Reservoir(s) (water surface elevations),
    - Sharon Heights Booster Pump Stations (pump operational status, speed settings, discharge pressures, and flows),
  - If MPMWD's or SFPUC's SCADA system(s) do not provide for historical archiving of these data, or it is not possible to get this information in digital format, then manual readings at key zone facilities that affect zone supply will need to be taken before, during, and immediately after each hydrant test.
- One copy of MPMWD's Health and Safety Plan for testing hydrants.

[1] It should be noted that the MPMWD has indicated that hourly flow data from the various turnouts is available, but is unsure if downstream pressure data is available. MPMWD staff will need to confirm whether this pressure data is available. In the event that pressure data is not available, West Yost proposes that Hydrant Pressure Recorders (HPRs) be deployed at hydrants downstream of each turnout so that system pressures can be recorded for the day that hydrant testing is performed.

Hydrant Testing Schedule

The hydrant testing is scheduled to occur over a two-day period on November 16th and 17th. The testing period is to occur between 8:00 AM and 5:00 PM; consistent with the City of Menlo Park's noise ordinance. West Yost will meet with MPMWD staff at or prior to 8:00 to have a brief field coordination meeting to review hydrant testing procedures and protocol (*i.e.*, where to go and what to do).[2] West Yost will also use this coordination meeting to distribute pressure gauges (hydrant wrenches to be provided by the MPMWD) necessary to complete the hydrant testing program. **Hydrant testing should continue until completion of the proposed 6 hydrant tests.**

Testing Requirements and Procedure

West Yost would like to conduct approximately six (6) hydrant flow tests within the MPMWD existing service area, along with two (2) alternate locations, if time permits, for a total of eight (8) proposed hydrant tests. Table 1 lists the 8 proposed hydrant test locations, which are also illustrated on Figure 1. As shown on Figure 1, the selected hydrants are distributed throughout the existing water system service area and were selected based on a specific pipeline diameter, material type, and pressure zone as summarized in Table 1. Table 1 also includes additional details specific to each hydrant test related to the number of closed valves required to conduct the test.

Table 1. Summary of Hydrant Test Locations

Test No.	Pipe Material	Pipe Diameter, in	Pressure Zone	No. of Closed Valves	No. of Hydrants Observed	Location	Comments
1	AC	8	Upper Zone	2	4	Near intersection of Sharon Road and Eastridge Avenue	-
2	AC	8	Upper Zone	1	4	Near intersection of Tioga Drive and Trinity Drive	-
3	AC	8	Lower Zone	2	3	Near intersection of Coleman Avenue and College Avenue	-
4	Unk	10	Lower Zone	0	4	Alley paralleling O'Brien Drive near Adams Drive.	-
5	DI	8	Lower Zone	4	4	Near intersection of Hamilton Avenue and Henderson Avenue	-
6	AC	10	High Pressure	1	4	Haven Avenue near Bayshore Road	-
7A	DI	6	Lower Zone	2	3	Near intersection of McKendry Drive and Blackburn Avenue	Alternate
8A	AC	10	High Pressure	2	4	Near intersection of Constitution Drive and Jefferson Drive	Alternate

[a] 6 hydrant test locations and 2 Alternate Test Locations

[2] As previously noted, in the event that pressure data downstream of the various SFPUC turnouts is not available, West Yost proposes that HPRs be placed at key hydrants near these locations, either (1) the day before or (2) before the first hydrant test, in an effort to capture pressure data for the day of hydrant testing.

Each hydrant test will involve maintaining flow from a single hydrant, while monitoring the residual pressures at three to four observation hydrants located near the flowing hydrant. The field observed static and residual pressure readings will then be used to confirm or adjust pipeline C-factors to calibrate the hydraulic model to observed field conditions. Hydrant test locations have been selected to isolate pipelines of a particular material type, diameter, and pressure zone and some tests will require that MPMWD personnel close one or more isolation valves prior to the test and re-open these isolation valves following the test.

The general testing procedure at each of the hydrant test locations is outlined below and illustrated on Figure 2.

Step 1. Before the test, flush the test (flowing) hydrant and each observation hydrant before attaching the pressure gage. (This allows sediments, which might damage the gage or cause faulty readings, to be flushed out from the hydrant.)

Step 2. Attach the pressure gage to the hydrant with the gage's test cock valve **open**. Slowly open the hydrant and bleed off the gage with the gage's test cock until the hydrant is fully pressurized.

Step 3. Close the gage test cock valve, and then measure the static pressures at the designated test hydrant and each observation hydrant.

Step 4. Flow the designated test hydrant and measure the discharge flow and pressure.

Step 5. Measure the residual pressures at the designated test hydrant and at each observation hydrant while the test hydrant is flowing.

Step 6. Continue monitoring pressure until the "all clear" is given by a West Yost employee. Record the static pressure and then detach the pressure gage. ***IMPORTANT**: Before closing the hydrant, be sure the gage's test cock valve is open and bleeding while the hydrant is being closed.*

At least one MPMWD staff member will be required at the flowing test hydrant and up to three (3) additional MPMWD personnel will be required in the field to measure static and residual pressures at the observation hydrants (refer to Attachment A). West Yost will provide up to three staff members to direct, oversee, and assist in the field data collection work effort.

It is anticipated that each hydrant test will take approximately one half hour and that each hydrant will be flowing for no more than 10 minutes during a test.

Testing Equipment

West Yost will provide 2.5-inch and 4.5-inch diameter Swivel Piezo Diffusers and pressure gages during the hydrant testing program. It is our recommendation that the 4.5-inch diameter Swivel Piezo Diffuser be used for all proposed hydrant tests. For any hydrant test where it is not possible to use this type of diffuser due to drainage or traffic control issues, an alternative method will need to be further evaluated and confirmed before the day of field testing.

MPMWD Responsibilities

MPMWD will be responsible for providing the following hydrant testing equipment:

- Hydrant wrenches, and
- Two-way portable communication for each of the testing personnel.

MPMWD is also responsible for notifying other MPMWD staff and residents about the scheduled hydrant testing, obtaining any approvals that may be required, providing proper drainage of the hydrant flow, and providing equipment for de-chlorinating[3] test water and personnel for traffic control, if required.

West Yost requests that MPMWD Ops staff review and inspect each of the proposed test locations before the testing date to identify any potential problems or hazards with the selected locations. Of particular concern will be the potential for flooding landscaping, building basements, or creating hazardous traffic conditions. Location and status of valves that will be closed during the hydrant testing should be checked. Detailed figures, which illustrate the flowing hydrant, observation hydrants and valves to be closed are provided in Attachment A.

SUMMARY OF HYDRANT TESTING PROGRAM

Hydrant testing will be performed as described above during the permitted noise ordinance hours and regular operations staff working hours. MPMWD is responsible for notifying other MPMWD staff and local residents/businesses about the hydrant testing program and coordinating with the MPFPD, as needed.

West Yost requests a conference call or meeting with MPMWD staff approximately one week before the scheduled testing day to review and identify any potential issues that may occur during hydrant testing such as unavailable SCADA system data. An Outlook meeting request will be sent to MPMWD staff to schedule a suitable meeting date and time. In the meantime, please feel free to contact Roberto (Bobby) Vera at 925-425-5624 if you have any questions or comments.

[3] Handling of water released from each hydrant test will need to comply with MPMWD Operations procedures and be consistent with MPMWD's NPDES permit for planned releases from hydrant tests.

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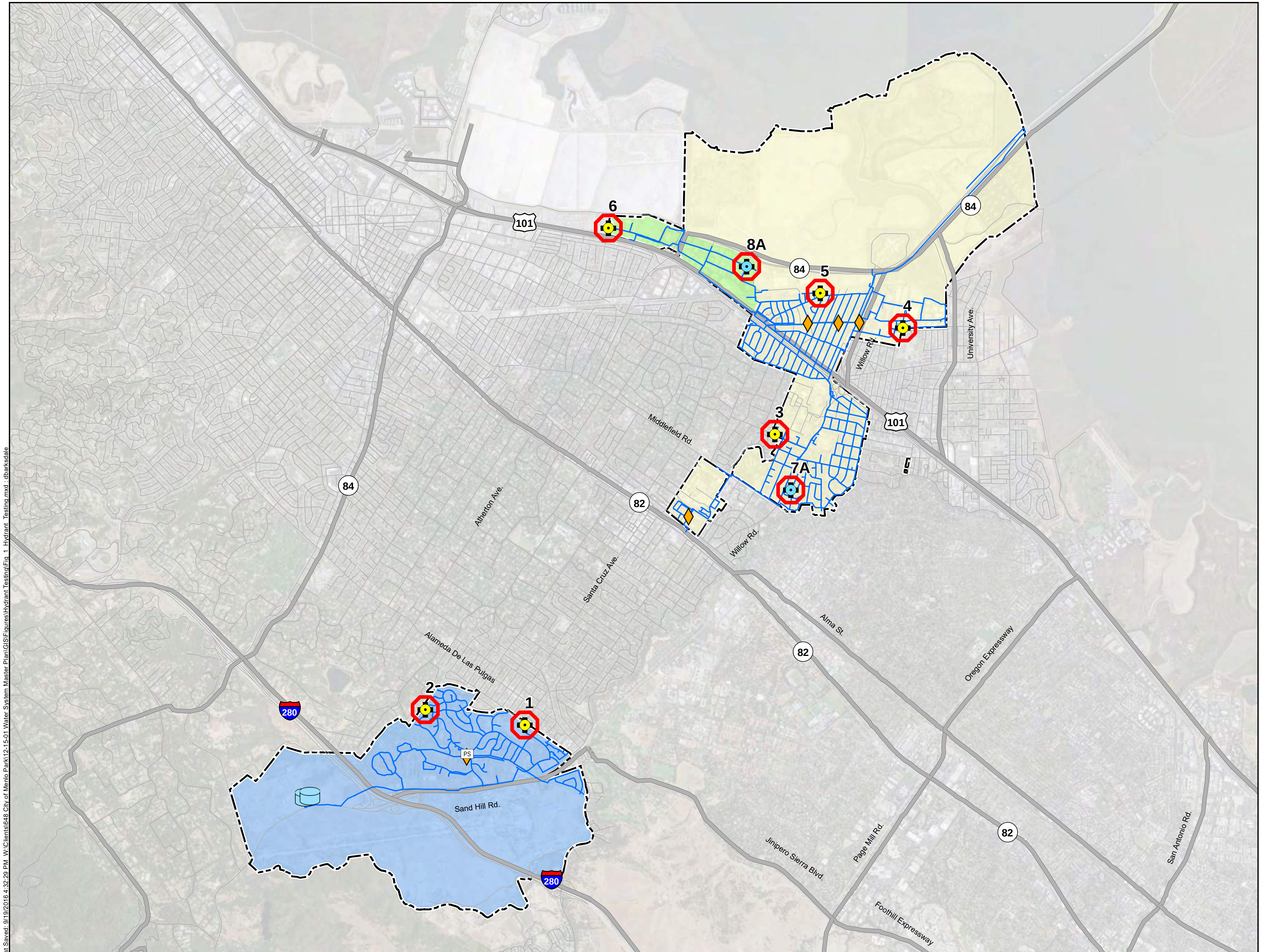

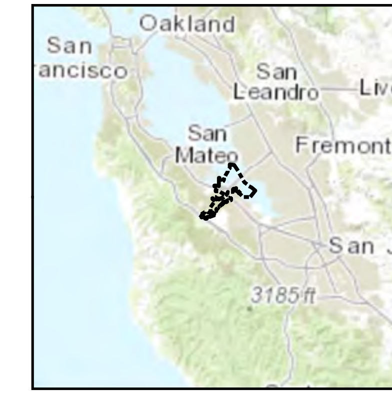

N

0 2,000 4,000
Feet

Symbology

- Hydrant Test Location
- Alternate Hydrant Test Location
- Sharon Heights Pump Station
- Sand Hill Reservoirs
- SFPUC Turnout
- Pipeline
- Menlo Park District Boundary
- High Pressure Zone
- Lower Pressure Zone
- Upper Pressure Zone

CITY OF MENLO PARK

WEST YOST ASSOCIATES

Figure 1

Proposed Hydrant Test Location Map

Menlo Park Municipal Water District
Water System Master Plan

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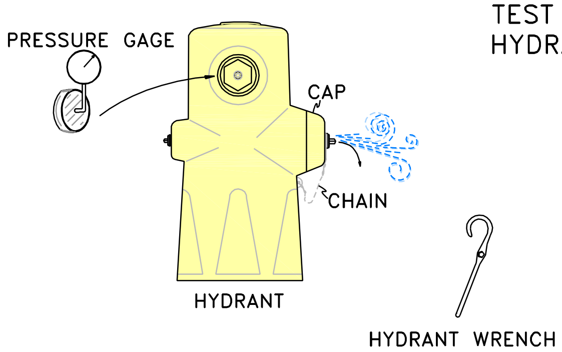
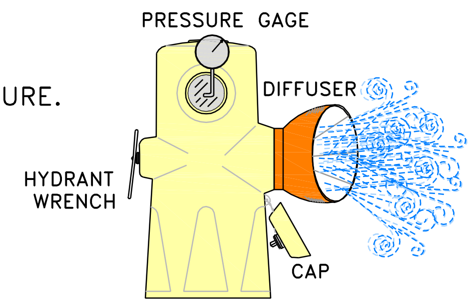
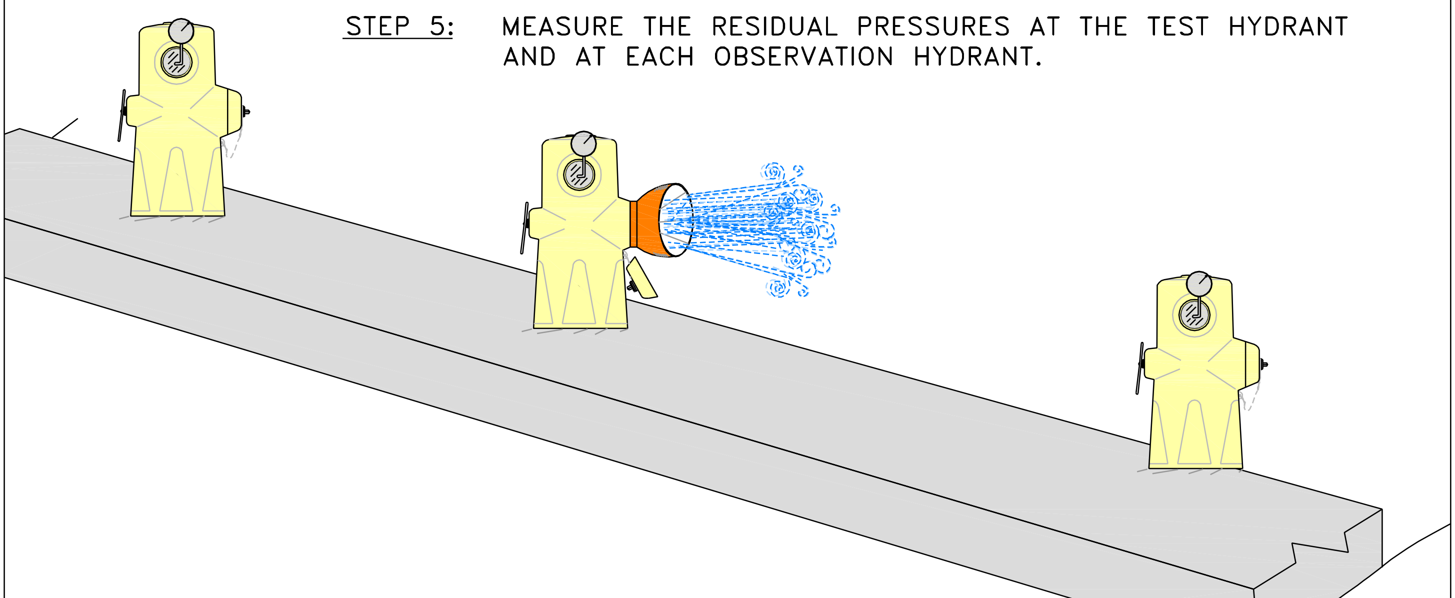
STEPS 1, 2 & 3: REMOVE HYDRANT CAP, FLUSH OUT HYDRANT AND MEASURE THE STATIC PRESSURES AT THE TEST HYDRANT AND AT EACH OBSERVATION HYDRANT.



STEP 4: FLOW THE DESIGNATED TEST HYDRANT AND MEASURE THE DISCHARGE FLOW AND PRESSURE.



STEP 5: MEASURE THE RESIDUAL PRESSURES AT THE TEST HYDRANT AND AT EACH OBSERVATION HYDRANT.



LEGEND:

NOT TO SCALE

CITY OF MENLO PARK

CITY OF MENLO PARK
WATER SYSTEM MASTER PLAN

FIGURE 2

HYDRANT TEST PROCEDURE

1777 Botelho Drive, Suite 240
Walnut Creek, California 94596
(925) 949-5800
FAX (530) 756-5991

WEST YOST ASSOCIATES

CAD FILE: w:/C/438/12-15-05/CAD/Figures/FIG 2_Hydrant Test.dwg DATE: 06-23-16 4:25pm DBarksdale

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ATTACHMENT A

Hydrant Test Location Sheets

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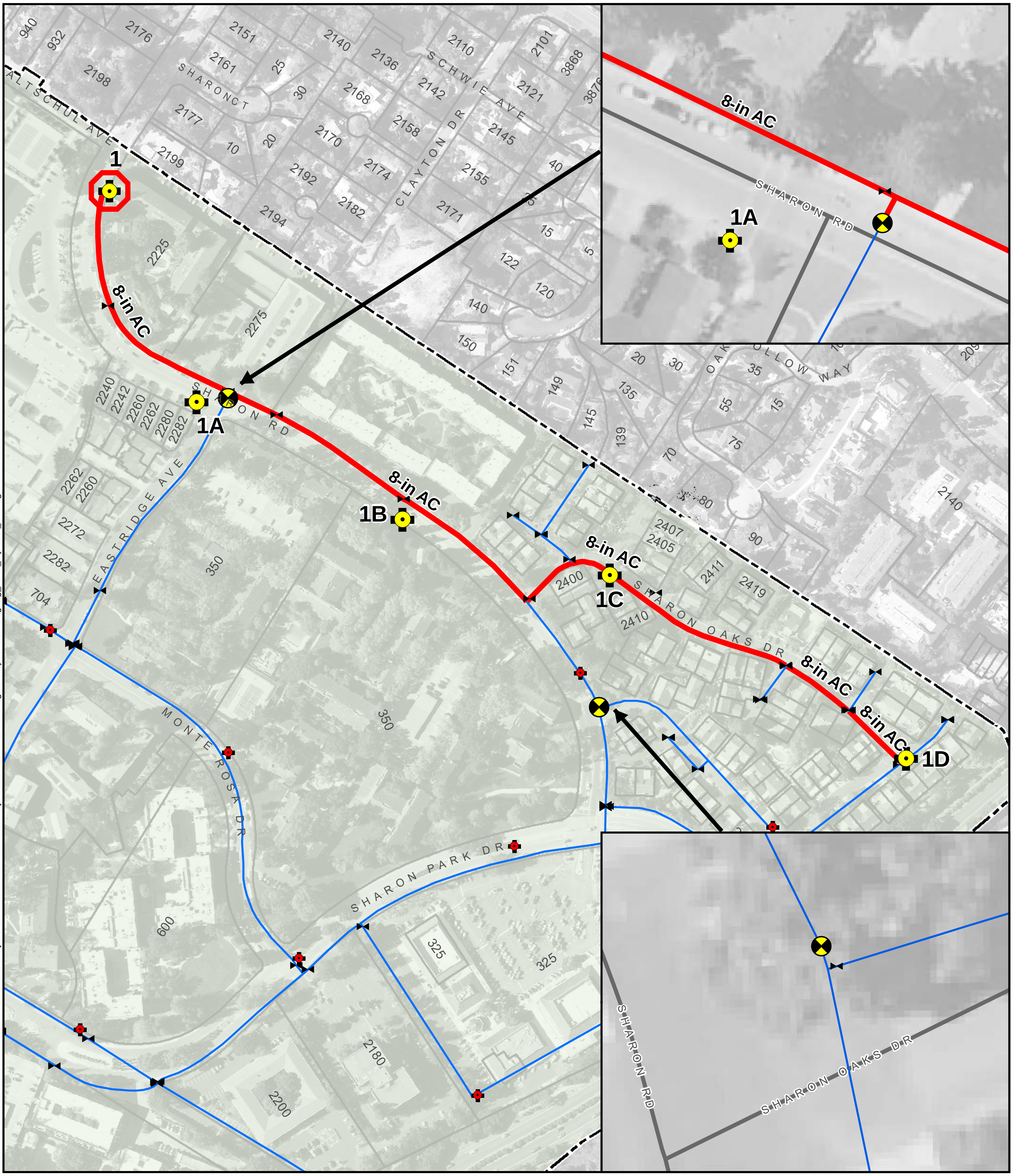

Flow Hydrant

Test Pipeline

Pipeline

Observe Hydrant

Hydrant

Closed Valve

Valve;

N

0 150 300

Scale in Feet

CITY OF MENLO PARK

WEST YOST ASSOCIATES

Figure A-1

Test 1

Menlo Park
Municipal Water District
Water System Master Plan
Hydrant Test Plan

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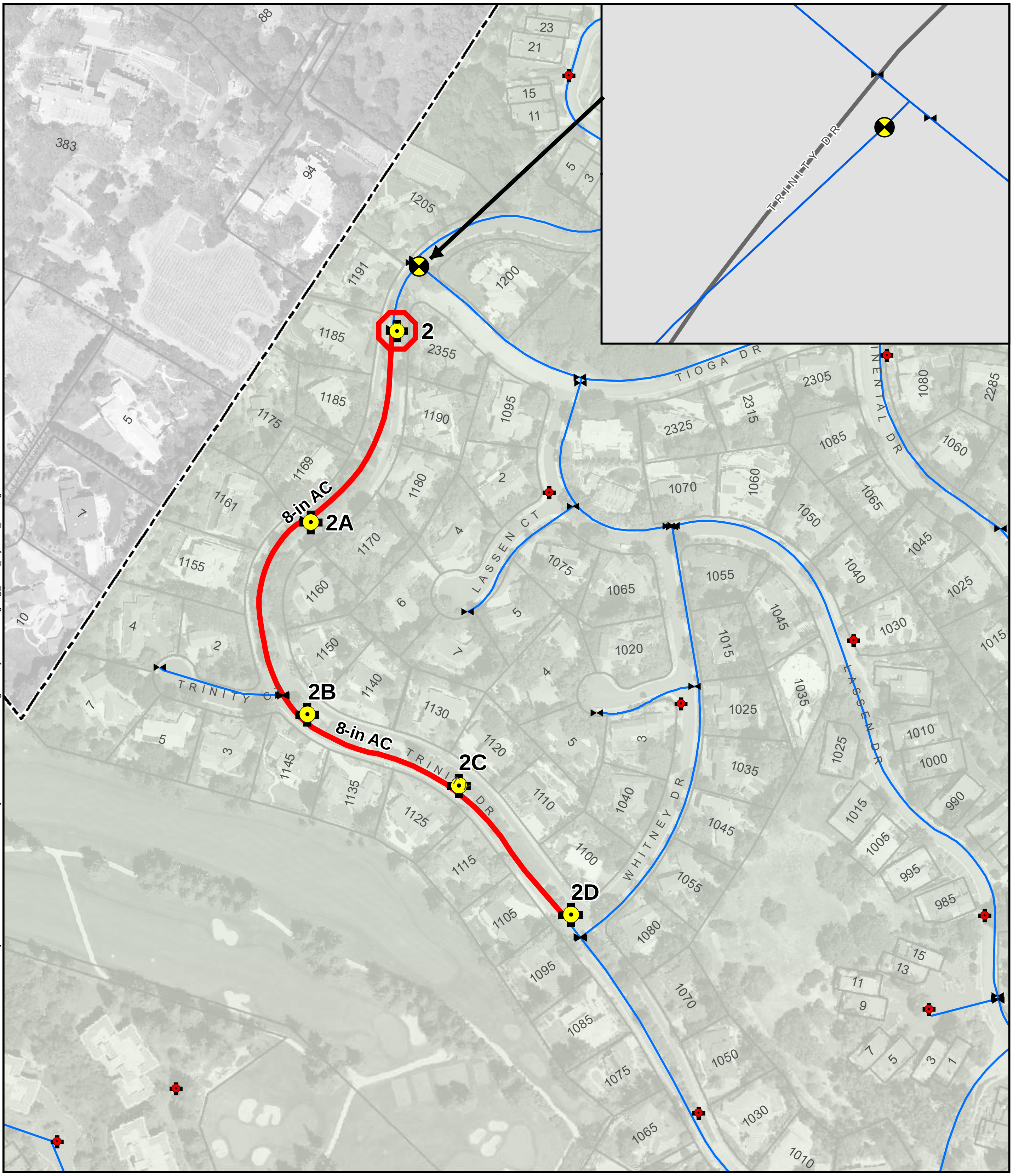

Flow Hydrant
Test Pipeline
Pipeline
Observe Hydrant
Hydrant
Closed Valve
Valve

0 125 250
Scale in Feet

CITY OF MENLO PARK

WEST YOST ASSOCIATES

Figure A-2

Test 2

Menlo Park
Municipal Water District
Water System Master Plan
Hydrant Test Plan

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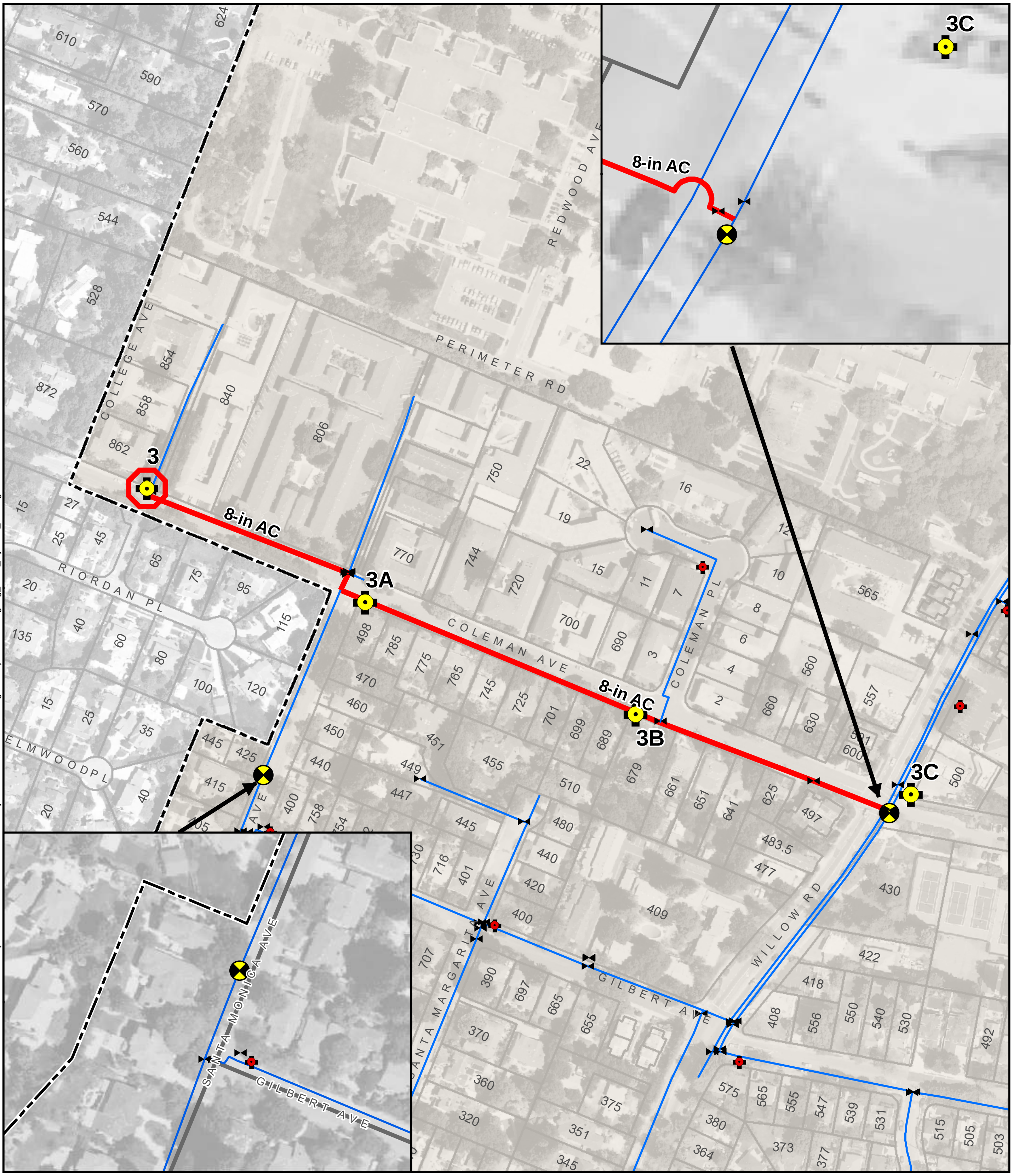

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Flow Hydrant

Test Pipeline

Pipeline

Observe Hydrant

Hydrant

Closed Valve

Valve

N

0 125 250

Scale in Feet

CITY OF MENLO PARK

WEST YOST ASSOCIATES

Figure A-3

Test 3

Menlo Park
Municipal Water District
Water System Master Plan
Hydrant Test Plan

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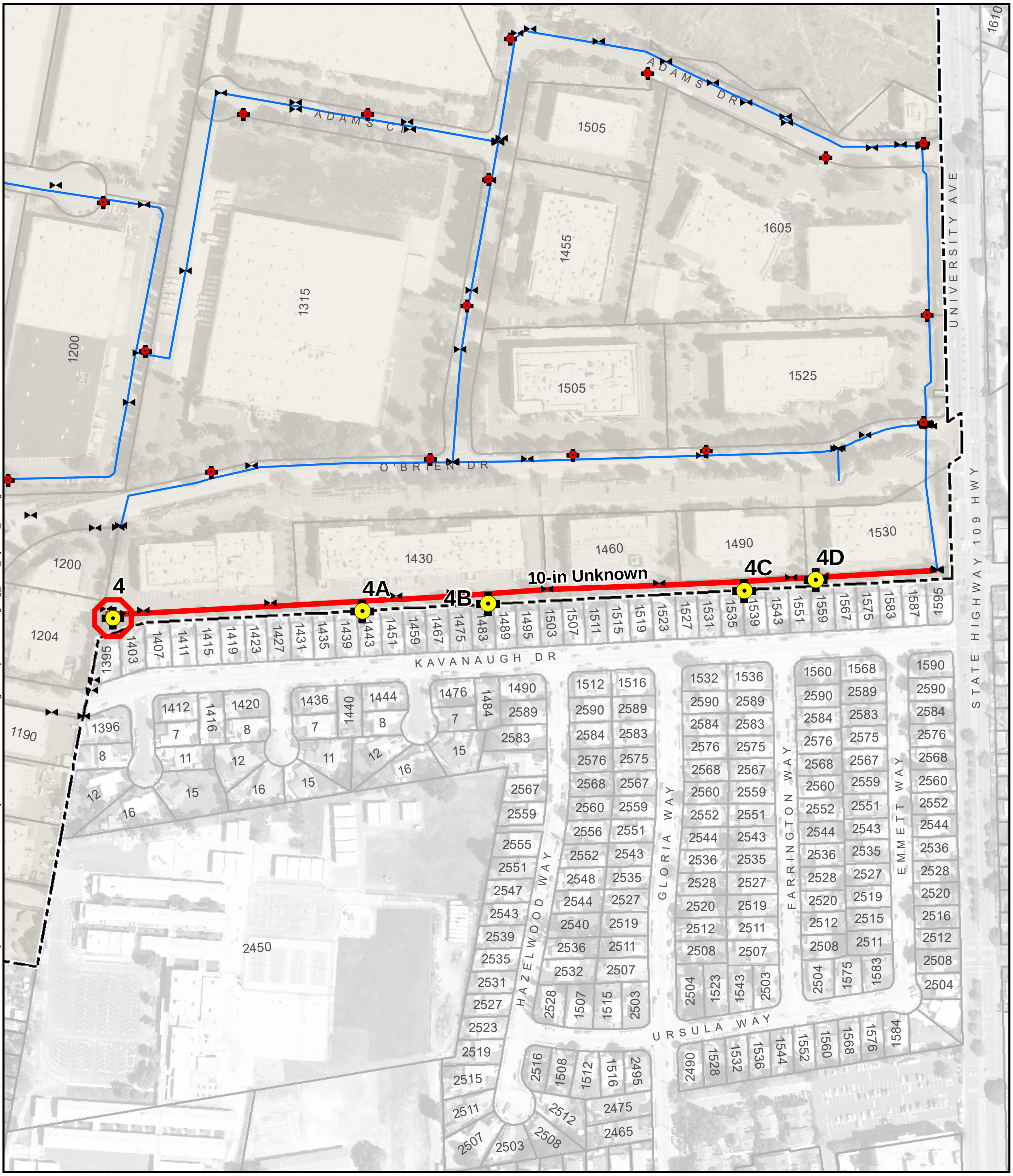

Flow Hydrant

Observe Hydrant

Hydrant

Closed Valve

Valve

Test Pipeline

Pipeline

N

0 150 300

Scale in Feet

CITY OF MENLO PARK

WEST YOST ASSOCIATES

Figure A-4

Test 4

Menlo Park
Municipal Water District
Water System Master Plan
Hydrant Test Plan

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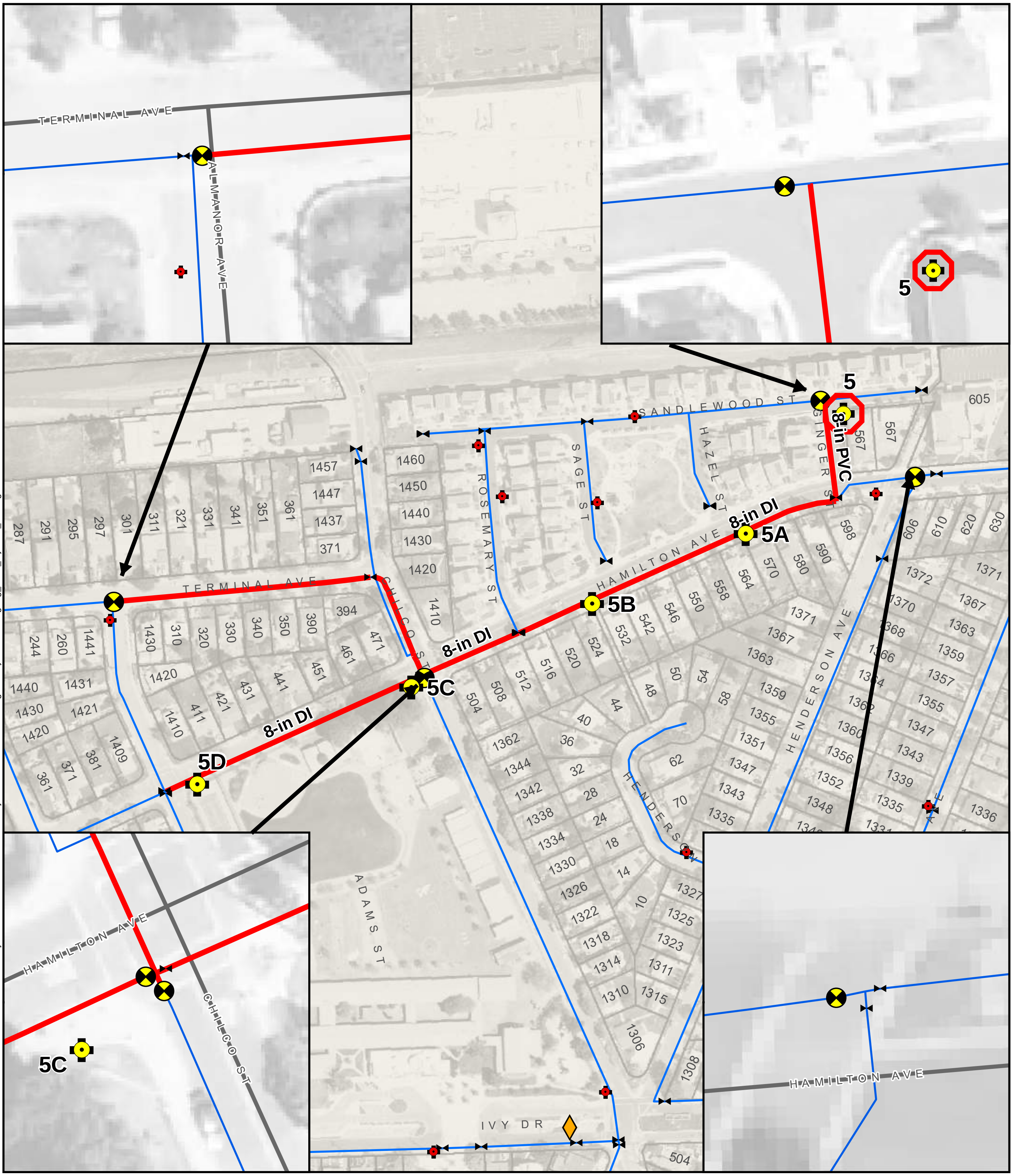

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Flow Hydrant

Observe Hydrant

Hydrant

Closed Valve

Valve

SFPUC Turnout

Test Pipeline

Pipeline

N

0 125 250

Scale in Feet

CITY OF MENLO PARK

WEST YOST ASSOCIATES

Figure A-5

Test 5

Menlo Park
Municipal Water District
Water System Master Plan
Hydrant Test Plan

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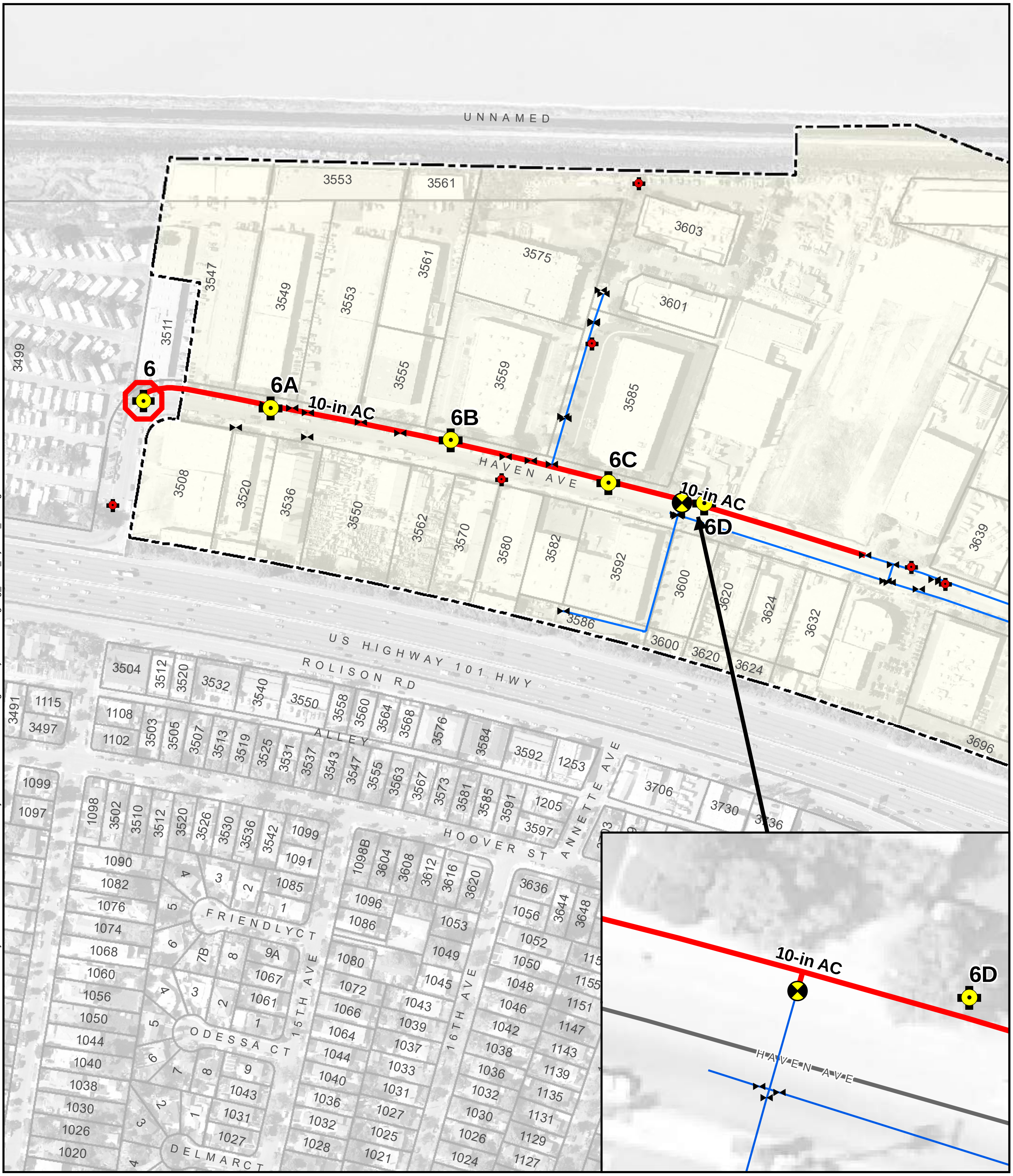

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Flow Hydrant
Test Pipeline
Pipeline
Observe Hydrant
Hydrant
Closed Valve
Valve

N

0 150 300
Scale in Feet

CITY OF MENLO PARK

WEST YOST ASSOCIATES

Figure A-6

Test 6

Menlo Park
Municipal Water District
Water System Master Plan
Hydrant Test Plan

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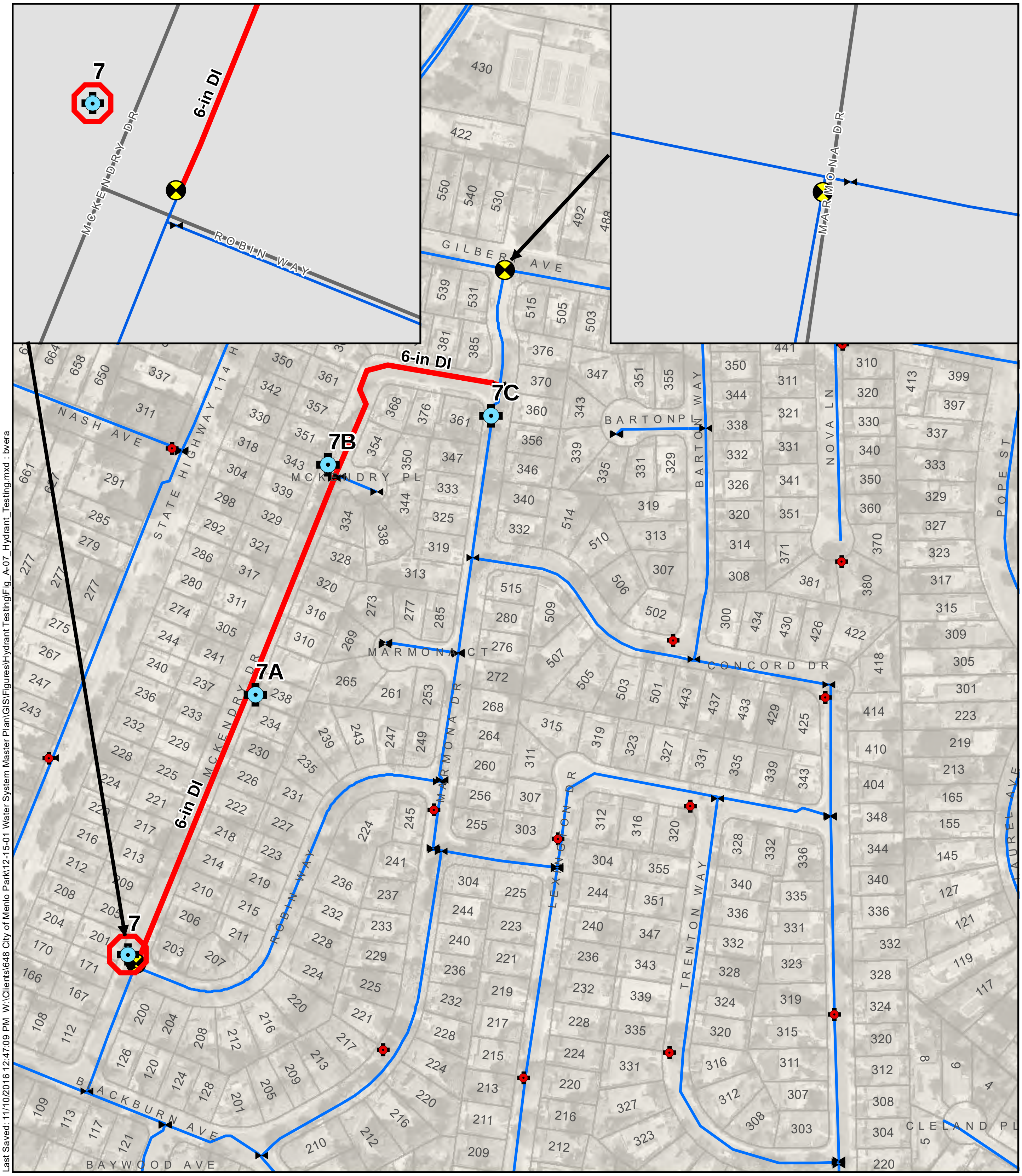

Flow Hydrant

Test Pipeline

Pipeline

Observe Hydrant

Hydrant

Closed Valve

Valve

N

0 125 250

Scale in Feet

CITY OF MENLO PARK

WEST YOST ASSOCIATES

Figure A-7

Alternate Test 7

Menlo Park
Municipal Water District
Water System Master Plan
Hydrant Test Plan

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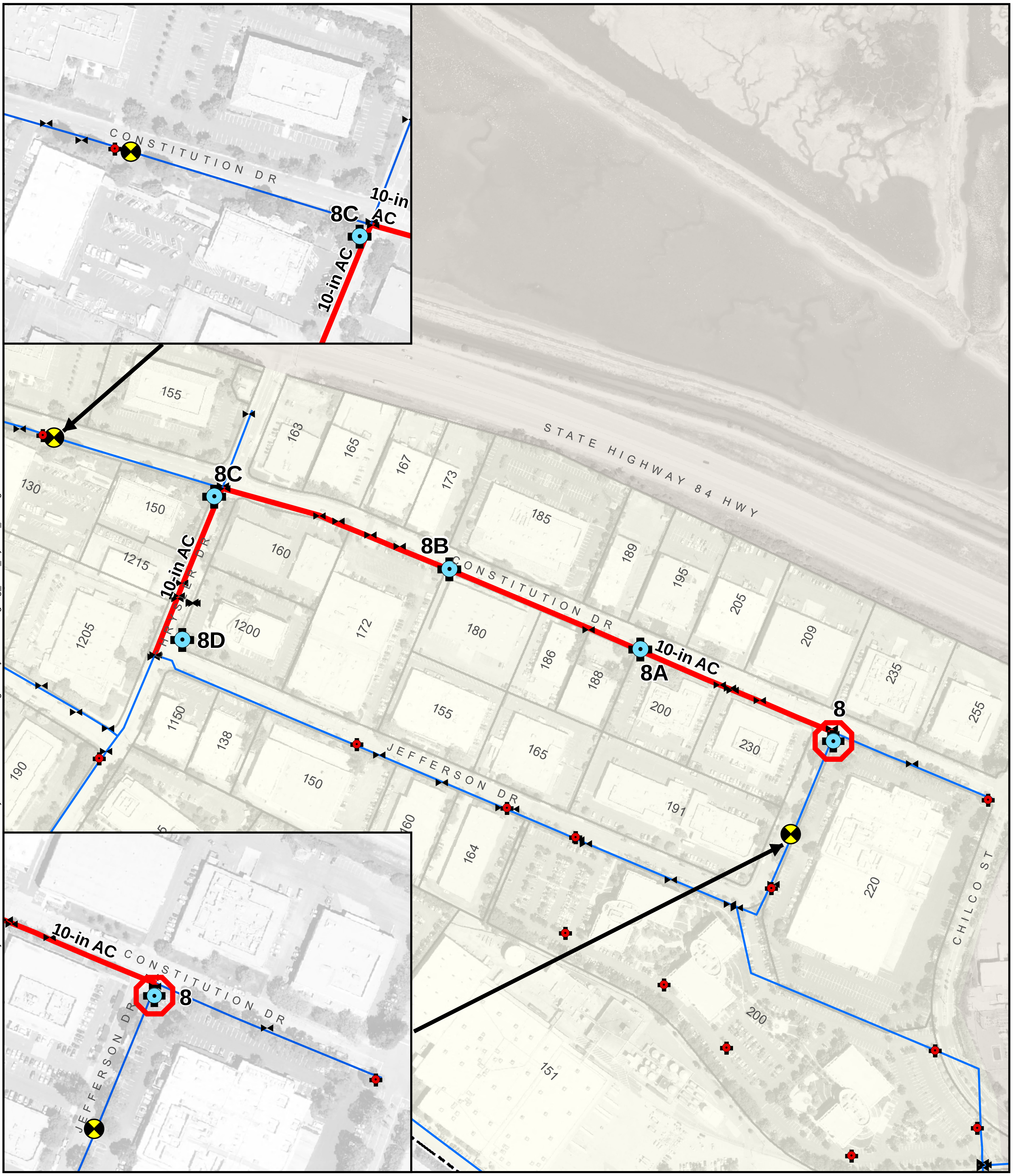

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Flow Hydrant
Observe Hydrant
Hydrant
Closed Valve
Valve

Test Pipeline
Pipeline

N

0 175 350
Scale in Feet

CITY OF MENLO PARK

WEST YOST ASSOCIATES

Figure A-8

Alternate Test 8

Menlo Park
Municipal Water District
Water System Master Plan
Hydrant Test Plan

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APPENDIX C

Menlo Park Seismic Vulnerability Assessment,
Don Ballantyne, Ballantyne Consulting LLC, July 2017

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Menlo Park Seismic Vulnerability Assessment

Don Ballantyne, Ballantyne Consulting LLC

July 2017

Executive Summary

Menlo Park Municipal Water (MPMW) is in a highly seismic area being located within one and one-half miles from the San Andreas Fault and 13 miles from the Hayward Fault. Ballantyne Consulting was retained as part of MPMW's Water System Master Plan to assess the vulnerability of the water distribution system and propose mitigation measures.

The water distribution system has three zones, the Upper Zone, Lower Zone and High Pressure Zone that receive water from the San Francisco Public Utilities Commission (SFPUC) via five turnouts from SFPUC's Regional Water System. MPMW is totally dependent on the SFPUC supply. The Upper Zone includes the two Sand Hill Reservoirs with a total of 5.5 million gallons (MG) of storage. The Upper Zone is, for the most part, on competent (non-liquefiable) soils, but because of its proximity to the San Andreas Fault, can expect very strong ground motions in a San Andreas earthquake. The Lower Zone and High Pressure Zone are in areas mapped as having moderate and high liquefaction susceptibility. These two pressure zones have no storage.

A Seismic Vulnerability Assessment of the system was conducted in 2004 by G&E Engineering. Since that report, MPMW has implemented several recommendations including: replacement of the Sharon Heights Pump Station, replacement of approximately 20,000 feet of pipe (an average of 1,500 feet/year, or about 0.5 percent of the pipeline system annually), and as part of this report, and is conducting a more detailed pipeline seismic vulnerability analysis. MPMW is also implementing an Emergency Water Supply project to construct three wells for emergency use. The first well will be completed by the end of 2017.

Since completion of the 2004 Seismic Vulnerability Assessment, the SFPUC conducted its $4.8 billion Water System Improvement Program, improving the reliability of the Regional Water System that supplies the MPMW. The SFPUC's performance criterion is to deliver average winter-month usage within 24 hours following any earthquake.

As part of the current study, it is recommended that both a geotechnical and structural assessment be performed on the two Sand Hills Reservoirs to assess their capabilities to withstand the scenario earthquakes. There is no record of previous assessments performed as part of the original design or thereafter, and code requirements have become more stringent since Reservoir No. 2 (the newer) was constructed in the 1990s.

As part of this study, a pipeline vulnerability assessment was conducted considering earthquake shaking intensity and liquefaction and associated lateral spread. In the Upper Zone, there is one small area mapped as being liquefiable. It is recommended that the liquefaction probability be quantified, and based on the results, the pipeline passing through that area be replaced with a seismic resistant pipe. In the high-level pipeline assessment, it was estimated that there would be approximately two pipeline breaks and two pipeline leaks in the Upper Zone. It is estimated that with those pipeline failures it would take thirteen hours to drain the reservoirs if they were full at the time of the event. With that much time, MPMW staff should be able to isolate one of the reservoirs to keep some water available for an emergency supply.

Much of the Lower Zone and High Pressure Zone are constructed on liquefiable soils. Most types of existing pipe do not perform well in earthquakes in liquefiable soils. In a San Andreas magnitude 7.9 earthquake, an estimated 92 pipeline failures will occur, and in a Hayward magnitude 7.1 earthquake, an estimated 31 pipeline failures will occur. These zones are totally dependent on supply from the SFPUC. The pipeline damage is estimated to be so extreme that it is unlikely the supply

can keep up, and the system will lose pressure. To mitigate that damage, it is recommended that MPMW place a high priority on replacement of approximately 50,000 feet of pipe with seismic resistant pipe (red and orange colored pipelines on Figure ES-1). Emergency wells are recommended to provide water in the immediate post-earthquake time frame.

MPMW's Emergency Response Plan should be updated with an Earthquake Annex added, and an Earthquake Recovery Plan developed that will provide direction to optimally restore the system.

A summary of recommendations and associated costs is included in Section 8.0 of this report.

1.0 Introduction

MPMW is in a highly seismic area, with the San Andreas Fault one and one-half miles to the west of the utility's Sand Hill Reservoirs, and the Hayward Fault approximately 13 miles to the east. Both faults are highly active. The water distribution system receives water from five SFPUC turnouts that supply three zones, the Upper Zone, Lower Zone, and High Pressure Zone. MPMW is totally dependent on the SFPUC supply.

The Upper Zone includes the two Sand Hill Reservoirs with a total of 5.5 MG of storage. The Upper Zone is, for the most part, on competent (non-liquefiable) soils, but because of its proximity to the San Andreas Fault, can expect very strong ground motions in a San Andreas event. The Lower Zone and High Pressure Zone are in areas mapped as having moderate and high liquefaction susceptibility. These two zones have no storage.

A Seismic Vulnerability Assessment was completed for MPMW in 2004 (G&E Engineering Systems, 2004). The 2004 study evaluated the effects of a moment magnitude (Mw) 7.9 San Andreas earthquake and a Mw 7.1 Hayward earthquake. An earthquake moment magnitude is a logarithmic scale taking into account the length and width of the fault slip plain, as well as the fault offset. The study estimated that for a Mw 7.9 San Andreas earthquake, SFPUC supplies would be disrupted for 20 to 30 days, and that MPMW would need 60 days to complete distribution system pipe repairs. Following a Mw 7.1 Hayward earthquake, SFPUC supplies were estimated to be disrupted for several hours to a day, and that MPMW would need 9 to 13 days to complete distribution system repairs. The report recommended a $5 million (2003 dollars) Seismic Improvement Program (SIP).

Since completion of the 2004 study, SFPUC has completed a $4.8-billion-dollar program to upgrade the SFPUC's regional and local water systems. MPMW has also completed some system upgrades.

This study, prepared as part of MPMW's 2017 Water System Master Plan, updates some of the elements of the 2004 report as follows:

- Pipeline analysis and replacement recommendations
- Sand Hill Reservoir analysis

Several recommendations have been removed with explanation as follows:

- Administrative Building and Emergency Operations Building detailed assessments
- Perform fire following earthquake analysis
- Install saltwater standpipes

This report also provides more in-depth information on some aspects of the expected system seismic performance, including the performance of the distribution system pipelines. The seismic vulnerability assessment scope of work included the following:

- Meet with MPMW to review seismic-related issues
- Review relevant documents, including the 2004 Seismic Vulnerability Assessment and 2009 Emergency Response Plan
- Conduct a site visit to perform a visual assessment of key water system facilities
- Prepare a pipeline vulnerability assessment to estimate vulnerability during specific earthquake events
- Document findings in a report

The analysis does not include structural analysis of any of the system facilities.

2.0 2004 Report Recommendations

The 2004 study recommended 12 elements in the SIP. Table 1 summarizes those recommendations, along with their current status and whether they are still recommended.

Table 1. Recommended List of Improvements from 2004 Report

No. (from 2004)	Recommendation from 2004 Vulnerability Assessment	Work Performed Since the 2004 Report	Comments from this analysis/report (2017)
1	Perform a more comprehensive hazard review, including field survey of geologic conditions along critical pipeline alignments, review of boreholes, update of liquefaction and landslide models.	No detailed hazard review has been performed since 2004	Association of Bay Area Governments (ABAG) liquefaction mapping was used for the pipeline analysis for this report but does not provide the level of detail required to assess the pipeline replacement program
2.1	Update pipeline analysis for updated hazards assessment.		Pipeline analysis was updated as part of this study using the ABAG liquefaction mapping. It should be further updated following the detailed hazard review
2.2	Establish pipeline replacement program		An updated pipeline replacement program is being developed as part of the Water Master Plan.
2.3	Conduct detailed seismic evaluations of the following:		
2.3.1	Sand Hill Reservoir Roofs	No detailed seismic analysis of the Sand Hill Reservoirs has been performed since 2004.	Roof/diaphragm seismic analysis is recommended. Geotechnical assessment of steep slopes surrounding the reservoirs is recommended. See section 4.1 of this report.
2.3.1	Administration Building	No detailed seismic analysis of the Administration Building has been performed since 2004.	Recommended for Public Works; not MPMW responsibility.
2.3.2	Emergency Operations Building	No detailed seismic analysis of the Operations Building has been performed since 2004.	Recommended for Public Works; not MPMW responsibility.

Table 1. Recommended List of Improvements from 2004 Report

No. (from 2004)	Recommendation from 2004 Vulnerability Assessment	Work Performed Since the 2004 Report	Comments from this analysis/report (2017)
2.3.4	Maintenance Building	No detailed seismic analysis of the Maintenance Building has been performed since 2004.	Recommended for Public Works; not MPMW responsibility. While light steel frame buildings are not likely collapse hazards, damage could result in red-tagging after an earthquake making them inaccessible.
2.4	Perform fire following earthquake assessment	No fire following earthquake analysis has been performed since 2004.	Response to fire following earthquake would fall under the responsibility of the Menlo Park Fire District
2.5	Perform benefit cost analysis of seismic retrofit alternatives	No seismic retrofits have been recommended on these facilities since 2004.	Benefit cost analyses should be performed on recommendations resulting from the detailed seismic analyses
2.6	Provide conceptual design sketches for retrofit alternatives	No seismic retrofits have been recommended on these facilities since 2004.	Conceptual design sketches should be developed for recommendations resulting from the detailed seismic analyses
2.7	Refine Seismic Improvement Program (SIP) budget	No seismic retrofits have been recommended on these facilities since 2004.	SIP budget estimates should be developed for recommendations resulting from the detailed seismic analyses
3	Install emergency bypasses on 2 backbone supply pipelines (pipe 12" and larger) where they cross liquefaction zones.	Some pipe has been replaced since the 2004 report, but no bypass lines.	A pipeline replacement program is recommended. See Section 5 of this report.
4	Install saltwater standpipes at regular intervals along the Bay waterfronts for emergency fire-fighting purposes	No saltwater standpipes have been installed since 2004.	MPMW is pursing wells for emergency water supply rather than saltwater standpipes. One well is completed and two additional wells are budgeted to enhance post-earthquake water supply reliability
5	Improve anchorage and/or restraint of MCCs at the Sharon Heights Pump Station	The Sharon Heights Pump Station has been replaced.	

Table 1. Recommended List of Improvements from 2004 Report

No. (from 2004)	Recommendation from 2004 Vulnerability Assessment	Work Performed Since the 2004 Report	Comments from this analysis/report (2017)
6	Implement non-structural anchorage program	No non-structural anchorage program has been implemented since 2004.	A non-structural anchorage program should be undertaken as part of the maintenance budget.
7.1	Develop post-earthquake operational and recovery plans	No post-earthquake operational or recovery plans have been developed since 2004.	Still recommended. Understanding the likely damage and a general approach to responding to the damage is important
7.2	Acquire emergency generators and portable pumps	No post-earthquake operational or recovery plans have been developed since 2004.	Dependent on operational and recovery plans
8	Install wells for emergency use	One well is completed and two additional wells are being planned to enhance post-earthquake water supply reliability	Continue implementation of the Emergency Water Supply Program by construction additional wells.
9	Develop a seismic design procedure manual for new pipelines and tanks	No seismic design procedures manuals have been developed since 2004.	American Society of Civil Engineers (ASCE) is developing a Manual of Practice for Seismic Design of Water and Sewer Pipelines. Adoption of this document may fulfill this recommendation. Menlo Park designs very few new tanks. It is recommended the seismic design criteria be reviewed for each new tank. This may fulfill this recommendation when it's complete.
10	Upgrade wood roofs on Sand Hill Reservoirs. Implement geotechnical mitigation.	Dependent of 2.3.1 (above) results	Upgrade wood roofs on Sand Hill Reservoirs. Implement geotechnical mitigation. (see 2.3.1 above). Dependent on assessment findings.
11	Upgrade remote telemetry unit cabinet including gel type batteries	Anchorage of these pieces of equipment may be adequate.	Anchorage should be checked as part of the non-structural anchorage program

3.0 System Updates Since 2004 Report

3.1 MPMW Improvements Since 2004

MPMW has done some work to seismically upgrade the system over the past 13 years:

- MPMW has been replacing vulnerable pipelines. Based on a review of the Geographic Information System (GIS), MPMW has replaced the following since 2004:
  - Steel – 51 feet
  - Polyvinyl Chloride (PVC) – 4047 feet
  - Ductile Iron Pipe (DIP) – 10,272 feet
  - Asbestos Cement (AC) – 2,549 Feet (possibly other material, AC may not have been available in this time frame)
  - Earthquake Resistant Ductile Iron (ERDP) – 2,778 feet (installation date not shown in GIS, estimated 2016)

  There is no documentation on the strategy used to select the segments that were replaced.

- MPMW is planning to upgrade the roof and cripple walls on the 3.5 MG Sand Hill reservoir.
- The Sharon Heights Pump Station was replaced.
- MPMW has implemented an Emergency Water Supply program to construct three wells. The first well will be completed by the end of 2017.

3.2 SFPUC Improvements Since 2004

Since 2004, the SFPUC has completed its $4.8 billion Water System Improvement Program. With that project, the SFPUC has committed to deliver water to BAWSCA members who receive water from the SFPUC Regional Water System with the following performance criteria following an earthquake:

- Deliver Average Winter-Month usage within 24 hours of any earthquake
- Deliver Average Day Demand within 30 days following the earthquake
- In both cases - delivered only to 70 percent of the turnouts within each region; the turnouts are not specified.

In discussions with Nicole Sandkulla, representing the Bay Area Water Supply and Conservation Agency (BAWSCA), she said they believed that even if some of MPMW's turnouts were inoperable, they could get water through interties with one of the neighboring utilities.

4.0 Facilities Review

Ballantyne Consulting performed a facilities review that included visual inspections of MPMW's reservoirs, pump station, (Pressure Reducing Valve) PRV vaults and Corporation Yard facilities.

4.1 Sand Hill Reservoirs

Reservoir Number 1, the west basin, is a 2 MG reservoir built in the 1960s, and Reservoir No. 2, the east basin, is a 3.5 MG reservoir built in 1996. These reservoirs are built on the top of a hill on a ridge just west of I-280. A plan view is shown in Figure 1.

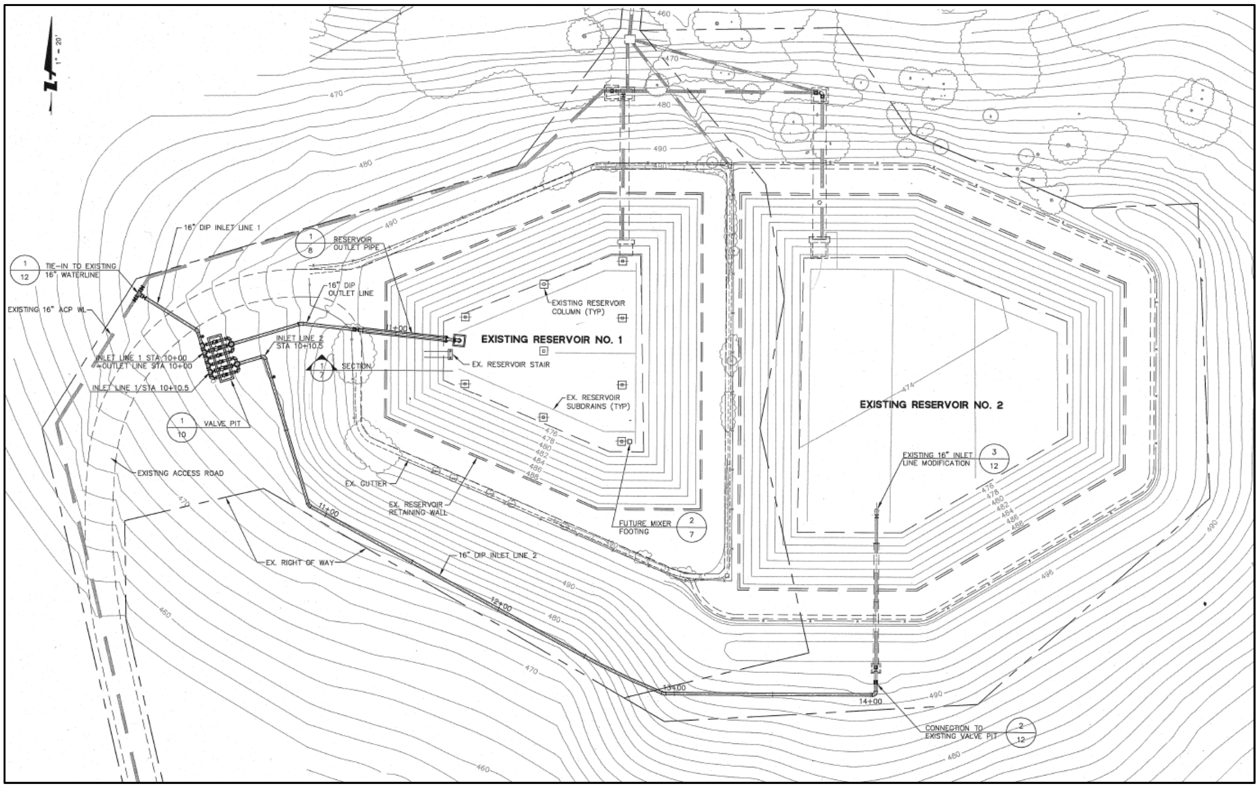

Figure 1. Plan View of Sand Hill Reservoirs

According to the 2004 Seismic Vulnerability Assessment, the construction style of both reservoirs was similar. Soil was excavated from the top of the hill; embankments were built to the finish grade. The reservoirs were constructed with the bottom being 14 feet below grade, and the top just above grade. The roof system was supported on 14-inch square columns on 4-foot square mat footings. The roof system was composed of plywood sheathing supported on wood rafters which are supported on steel wide flange beams. This roof diaphragm system transfers the lateral load to the reservoir walls which then transfer the load to the concrete walls and foundation through plywood shear walls (cripple walls).

The ground motions at the reservoir site are very strong due to the reservoir's proximity to the San Andreas Fault. The USGS reports during the maximum credible earthquake (MCE), the estimated peak ground acceleration (PGA) (0 second period) is 116 percent of gravitational acceleration, and approaching 290 percent of gravitational acceleration in the 0.10 to 0.50 second period range. For a design earthquake, the comparable ground motions are 80 percent PGA, and 190 percent of gravitational acceleration in the 0.10 to 0.50 second period range as addressed in American Society of Civil Engineers (ASCE) 7 and the International Building Code. These lateral loads are larger than would have been required in the Uniform Building Code (UBC), in effect when the reservoirs were designed. These ground motions can be further amplified due to ridge top effects, i.e., focusing energy on the tops of hills. ASCE 7-10, "Minimum Design Loads for Buildings and Other Structures" requires that reservoirs containing water used for fire suppression are classified in Risk Category 4 and must be designed with an importance factor of 150 percent of the normal lateral design load. The combination of these three considerations results in very large ground motions that will act on the reservoir site (geotechnical) and reservoir structure.

During a site visit, a potential for geotechnical failure of the slopes surrounding the reservoirs was identified. There are very steep slopes, and there is no record of a geotechnical assessment performed for either Reservoir 1 (1960s) or Reservoir 2 (1996) (Photos 1 and 2). The concern is that an embankment could fail due to strong ground shaking, resulting in collapse of a portion of the reservoir wall. It is recommended that a geotechnical engineer be retained to investigate the geotechnical stability of the site.

Photo 1. Steep Reservoir Embankment from the Southwest

Photo 2. Closer view steep reservoir embankment

The reservoirs have large roofs. The lateral loading from these large roofs must be transferred to the reservoir walls, and then the reservoir foundation. As noted above, the earthquake lateral load forces are very large, exceeding those included in the UBC. There is a concern that the reservoir roofs could fail, and fall into the reservoir, which could result in plugging the outlet, restricting flow, and impacting water quality. Further, water waves could develop inside the reservoir (sloshing) that could impact the cripple walls, blasting holes in the sidewalls, weakening the structure.

There is no record of a seismic structural analysis done for either Reservoir No 1, 1960s vintage, or Reservoir No. 2, 1996 design.

Given the seismic loading issues discussed above, it is recommended that a licensed structural engineer review the seismic design of both Reservoir 1 and Reservoir 2. At a minimum, it is recommended that a grating be installed over the reservoir outlets to keep out debris following an earthquake.

There has been discussion of use of earthquake valves on Reservoirs 1 and/or 2 to contain water in the reservoir if distribution pipelines are heavily damaged during an earthquake. The objective of an earthquake valve is to maintain storage in the reservoir rather than allowing it to drain out through pipeline breaks. The water could be used for fire suppression at desired locations once damaged pipelines have been isolated by closing the appropriate valves. The water could also be used for fire protection by filling tank trucks from the reservoir and transporting it to the desired locations. The water could also be used for potable use in the event the SFPUC supply was out of service for longer than anticipated. The water could be transported to distribution points with tank trucks.

Earthquake valves can be any type of valve with a backup power system that would close the valve in the event of an earthquake. The valve would typically be activated using a signal from a local Programable Logic Controller (PLC) which would receive input from a local ground motion instrument and a flow meter on the reservoir outlet. It would be set so that if the ground motion exceeded some predetermined threshold (e.g. a peak ground acceleration (PGA) of 25 percent of gravity), the PLC would query the flow meter measuring water exiting the reservoir; if the flow is large, indicating major pipeline breaks, the PLC would send a signal to the valve to close. Oftentimes butterfly valves are used for earthquakes valves. Operators can use electric motors (with battery backups), or pneumatic operators with nitrogen bottles or air tanks storing energy for closure.

An earthquake valve should only be employed on a reservoir if there is a redundant supply to the pressure zone it serves. Without redundancy, there would be an immediate loss in water for water sprinklers and water for fire suppression. In the case of the Upper Zone, there are two reservoirs, so one could be isolated with an earthquake valve. However, the on-site piping would have to be modified so valve closure would keep one reservoir on line.

To further evaluate the need for earthquake valves, potential flows were evaluated for potential pipeline break scenarios, evaluating distribution system piping in the Upper Zone, and were compared with the reservoir storage volume. As described further in Section 5.0 – Distribution System Analysis, pipe damage in the Upper Zone is estimated to be limited, with only two breaks and two leaks estimated for a San Andreas magnitude 7.9 earthquake scenario. The large majority of the pipe in the Upper Zone is 6-inch or 8-inch diameter, so those pipe diameters are where the failures would likely occur. The flow on a totally ruptured 8-inch line could be on the order of 1,500 gallons per minute (gpm) (estimated based on a 10 foot per second velocity (fps) times the cross-sectional area of the pipeline) from each direction of the break; say a total of 2,500 gpm for each break. If the two breaks were to occur on two 8-inch lines that were not influenced hydraulically by one another, they could demand 5,000 gpm. One 8-inch pipe leak is estimated to produce 1,000 gpm, two leaks, double that. The estimated two breaks and two leaks in the Upper Zone could draw 7,000 gpm.

Much of the pipe on Sand Hill Road is 16-inch diameter. The GIS database shows the I-280 crossing to be AC pipe, which performs moderately well when subjected to earthquake shaking. At 10 fps times the cross section, the flow from the reservoirs by the 16-inch pipe is estimated to be 6,300 gpm. Even at 7,000 gpm, the 5.5 MGs of storage in the Upper Zone could potentially provide storage for about 13 hours if the reservoirs started full, and they were not damaged by the earthquake. It is assumed that, in lieu of an earthquake valve, an operator could be dispatched to the reservoirs, and if it was prudent, close the isolation valve well within that 13-hour time frame to keep the reservoirs from totally draining.

The SFPUC system performance criteria is to deliver water to 70 percent of the turnouts within 24 hours. Considering this criterion, there is potential that any single turnout may not be operable within 24 hours, although there are interties with adjacent utilities that may allow receiving water from the SFPUC system.

The advantages of installing an earthquake valve on Reservoir 2 (the larger reservoir) are as follows:

1. Minimize the potential of draining the reservoirs due to distribution pipeline damage following an earthquake.
2. Maximize the amount of water stored in the reservoir following an earthquake using an automated control system. The water can be used for fire suppression of drinking particularly within the first 24 hours following an earthquake when the SFPUC supply may not be available.
3. Closure of the isolation valve is not dependent on operations staff getting to the reservoirs following the earthquake. Staff availability and access/access to the reservoirs may be limited following the event.

The disadvantages of installing an earthquake valve on Reservoir 2 (the larger reservoir) are as follows:

1. Potential for valve system failure during the earthquake, or at other times, isolating the water and not making it available for use.
2. Cost of installation of the earthquake valve and re-piping the reservoir site to accommodate the valve design function.
3. Cost of maintaining the valve on an ongoing basis.
4. Cost/time commitment to monitor the valve and system function following the earthquake.

MPMW is in the process of developing three wells to use for post-earthquake emergency supply. One is currently operational, and the other two will be operational within the next few years. Water from these wells would be available for fire suppression or drinking following an earthquake, transported by tank truck to serve the Upper Zone if it was required. (See advantage No. 2 above) Therefore, with the availability of this emergency supply, and the ability to manually isolate the reservoirs before they drain, an earthquake valve for the Upper zone is not recommended.

4.1 Sharon Heights Pump Station

MPMW replaced the Sharon Heights Pump Station in 2016, designed to modern seismic standards. The pump station includes a diesel power emergency generator (Photo 3). It is recommended that MPMW make provisions to refuel the generator considering post-earthquake emergency conditions. Options include transporting diesel fuel from MPMW maintenance facility, or contracting with a fuel supplier.

Photo 3. Diesel driven emergency generator at the Sharon Heights pump station. Fuel storage in the base of the unit limits capacity.

4.2 PRV Vaults

During the site visit, several typical pressure reducing valve vaults were opened for observation. It was noted that vertical pipe bracing was, in most cases, not anchored to the floor of the vault, and that there was no lateral bracing (Photo 4). It is recommended that both vertical and lateral pipe braces be installed in each vault. In vaults with short pipe runs, less than 8 feet, one set of braces should be adequate. Otherwise two sets should be installed. The greatest load will come from the massive valve bodies, so the braces should be anchored as close to the valves as feasible.

Photo 4. PRV Vault – Vertical pipe bracing not anchored to the floor; no horizontal bracing.

4.3 Corporation Yard Buildings

During the site visit, a brief meeting was held in the Corporation Yard offices. Other buildings were observed while walking around the yard. We understand that they were built in the 1970s. These appear to be light steel frame buildings, with the structural system being a combination of moment frame in one direction and braced frame (cross bracing) in the other direction. Interior walls have been constructed. The exterior walls support minimal weight, so collapse is unlikely. However, in the strong ground motions expected from a San Andreas event, there is potential for failure of cross bracing elements. This is particularly true for a building design of this vintage. This could lead to lateral displacement of the frame and associated cracking, and ultimately being red-tagged. If they were red-tagged, they could not be used. As these are facilities will be important during emergency response, it is recommended that a structural engineer review their design, and that they be retrofitted accordingly.

In Table 1, recommendation 7.1 is to "Develop post-earthquake operational plans". One of the elements of that plan should be to identify emergency equipment that may be required to operate the system when some installed equipment have failed. Pumps and hoses to move water around major pipeline breaks is an example. MPMW should plan for storage of this equipment at the Corporation Yard, making it readily accessible in the immediate aftermath of an earthquake.

5.0 Distribution System Analysis

The Menlo Park pipeline system was evaluated using the American Lifelines Alliance (ALA), Seismic Fragility Formulations for Water Systems. (ALA, 2001). This method uses fragility curves that can be applied to water system components to evaluate the probability of damage from earthquake hazards. Damage estimates are expressed as pipeline repair rates, breaks and leaks. This approach has been widely used for many pipeline loss assessments. The general approach is to quantify both earthquake shaking (wave propagation) intensity using peak ground velocity (PGV) and permanent ground deformation (PGD) hazard parameters to estimate the damage to the system pipelines. The ALA methodology includes fragility relationships for both PGV and PGD inputs. Variables are included in those relationships representing different pipe materials.

United States Geological Survey (USGS) ShakeMap scenarios for a Magnitude 7.9 earthquake on the San Andreas Fault, and a Magnitude 7.1 event on the Hayward Fault were used for the analysis. Peak Ground Velocity (PGV) used for assessing pipe vulnerability to wave propagation were available as part of the scenarios. For the San Andreas Fault scenario, PGVs ranged from 82 centimeter per second (cm/sec) on the westerly edge of the service area near the fault, to 48 cm/sec near San Francisco Bay. The PGVs for the Hayward Fault scenario were much lower, ranging from 12 to 6 cm/sec.

Liquefaction-related lateral spreading has a much more dramatic impact on the pipe than PGV. Liquefaction susceptibility mapping was used from ABAG, that showed liquefaction susceptibility zones ranging from Very Low to High. Figure 2 shows a map of the liquefaction susceptibility zones overlaid with the pipeline system showing diameter (line width) and pipe material (pipe color). An estimate of the probability of the various liquefaction susceptibility areas was assigned based on other similar projects. As this is an important parameter, in the future the City should develop more detailed estimates of this probability and associated permanent ground deformation (PGD). The probability and PGD are dependent on the earthquake shaking intensity, so they are larger for the San Andreas Fault scenario than for the Hayward Fault scenario. Table 2 shows the probability and PGDs for each scenario for the range of liquefaction susceptibilities.

Table 2. Liquefaction Probability and PGD for Susceptibility Zones for San Andreas and Hayward Fault Scenarios (Note 1)

	San Andreas Scenario		Hayward Scenario	
Susceptibility Zones	**Probability of Liquefaction resulting on PGD**	**PGD (Note 1)**	**Probability of Liquefaction resulting in PGD**	**PGD (Note 1)**
Very Low	Minimal	0"	Minimal	0"
Low	Minimal	0"	Minimal	0"
Moderate	25%	6"	10%	2"
High	50%	12"	25%	6"

Note 1: PGD – (permanent ground deformation), is a distance a block of soil is expected to move during an earthquake (typically down-hill or towards a free face, and to remain in that position within a few minutes after the earthquake shaking has stopped.

Almost three-quarters of the distribution system pipe is in the high or moderate liquefaction zones found primarily in the Lower Zone and High Pressure Zone. The Upper Zone is primarily on the low and very low liquefaction zones (Figure 2).

The system includes 288,873 feet of pipe with diameters ranging from 2- to 18-inches as represented in the GIS database. The pipe material, length, assumed joint type, and K1 and K2 values for each are shown in Table 3. K1 and K2 values are constants used in the equation to represent the expected performance of the various pipe materials. The K1 and K2 values for cast iron are 1.0, representing the most vulnerable pipe. The K1 and K2 values for earthquake resistant ductile iron pipe (ERDIP) are 0.1, representing the least vulnerable pipe. The joint type is based on the consultant’s knowledge of common joint systems used for particular types of pipe material. To some degree it is dependent on the age of the pipe. If the incorrect joint types are assumed, it could result in different K1 and K2 values, increasing or decreasing the estimated number of failures. The K1 and K2 values for specific pipe materials are taken directly from the ALA document. When there are no values for specific types of pipe in the ALA document, K1 and K2 values are estimated based on similar types of pipe and pipe joints. The ALA fragility relationships assign variables to each pipe material depending on its relative performance.

Table 3. Pipe Material, Length, Joint Type, K1 and K2 Values						
Material	Acronym	Length, (ft)	Percent of Total	Assumed Joint Type	K1 Value	K2 Value
Asbestos Cement	AC	152,223	52.7	Coupling with Rubber Gaskets	0.5	0.8
Ductile Iron Pipe	DIP	82,320	28.5	Bell and spigot (B&S) with elastomeric gaskets	0.5	0.5
Unknown	Unk	25,472	8.8	Assume to be AC pipe	0.5	0.8
Polyvinyl Chloride	PVC	18,304	6.3	B&S with elastomeric gaskets	0.5	0.8
Cast Iron Pipe	CI	5,009	1.7	Leaded B&S	1.0	1.0
Earthquake Resistant Ductile Iron	ERDP	2,778	1.0	Restrained joint allowing movement rubber gaskets	0.1	0.1
Unknown	DW	1,144	0.4	Assumed to be similar to AC	0.5	0.8
High Density Polyethylene	HDPE	493	0.2	Fused	0.3	0.3
Unknown	ENC	450	0.2	Assumed to be similar to AC	0.5	0.8
Unknown (steel?)	FS	440	0.2	Welded	0.3	0.3
Steel	Steel	239	0.1	Welded	0.3	0.3
Total		**288,872**	**100.0%**			

In the Assumed Joint Type column, it states the basis for assuming the K1 and K2 values. Unknown pipe materials (Unk and DW) are assumed to have the same performance attributes as AC. FS is assumed to have similar attributes as steel. These pipe materials make up a small percentage of the system (totaling less than 1 percent), and would only have a small influence on overall system performance. However, the pipe designated as "Unknown" Unk, makes up almost 9 percent of the system. It would be beneficial to determine what type(s) of pipe it is.

The total pipe lengths by pressure zone are:

- Upper: 81,554 (28 percent)
- Lower: 183,907 (64 percent)
- High Pressure: 23,411 (8 percent)

The ALA fragility relationships used to calculate the repair rate are:

For wave propagation, **RR = K1 x 0.00187 x PGV**

Where RR = repairs/1,000 feet of pipe
PGV (in/sec)

For PGD, **RR = K2 x 1.06 x** $\mathbf{PGD^{0.319}}$

PGD (inches)

The number of pipe failures is calculated by multiplying the pipe repair rate (RR, repairs/1,000 feet of pipe) times the pipe length (in 1,000s of feet).

The break-down of the number of leaks and breaks is dependent on the hazard environment the pipe where the pipe is located. Repair rates include both leaks and breaks. Repair rates are calculated separately for PGD and PGV. Repair rates for PGD are applied to the length of pipe in the particular liquefaction susceptibility zone times the probability of liquefaction in that zone (See Table 2). Repair rates for PGV are applied to all other pipe. The results of the analysis are shown in Table 4 grouped by earthquake scenario, PGD- and PGV-related failures, and leaks versus breaks.

The methodology provides direction in segregating failure type as follows:

- PGD-related failures – 80 percent breaks and 20 percent leaks
- PGV-related failures – 20 percent breaks and 80 percent leaks

Breaks are described as loss of hydraulic continuity, e.g. the loss of the ability to transmit water from point A to point B. “Breaks” would include separation of a pipe joint by more than approximately an inch, or the blowout of the pipe wall. A break results in significant loss of water; a pipe break results in the pipe being non-functional, and must be repaired before the immediate service area can be put back into service. A leak is simply a failure resulting in loss of water. A leak does not necessarily need to be restored immediately for the immediate service area to be put back into service. A leak versus a break is based on the ground deformation associated with each hazard parameter. PGD can range from inches to many feet, but PGV is typically fractions of an inch. Pipe with rigid joints such as cast iron pipe with leaded joints is particularly vulnerable to PGV, but pipe with elastomeric joints can absorb all but the very strongest PGV movements.

The pipeline leak and break rates are shown for the San Andreas scenario on Figure 3, and the Hayward scenario on Figure 4. The figures show the pipe repair rates by color as noted in the figure legend. The higher the failure rate the more failures per unit length are expected for that particular pipe. This information can be used by the City to prioritize pipe replacement. However, there is no firm threshold above which pipelines need to be replaced. The highest failure rates are typically a function of vulnerable pipe materials (e.g. cast iron) and soils subject to PGD (liquefiable soils).

Table 4. Pipeline Failures for PGD, PGV, Total, and percentage by zone, all by zone

	Permanent Ground Deformation (PGD) Related Pipe Failures			Peak Ground Velocity (PGV)-Related Pipe Failures			Total PGD and PGV			Percentage by Zone (2)	
Pressure Zone	**Leaks**	**Breaks**	**Total**	**Leaks**	**Breaks**	**Total**	**Leaks**	**Breaks**	**Total**	**Failures**	**Pipe Length in Zone as a percentage of total pipe length**
San Andreas Earthquake Scenario											
Upper	0	2	2	2	0	2	2	2	4	4%	28%
Lower	16	65	81	2	1	3	18	66	84	88%	64%
High Pressure	2	7	9	0	0	0	2	7	9	9%	8%
Total (1)	**18**	**74**	**92**	**4**	**1**	**5**	**22**	**75**	**97**	**100%**	**100%**
Hayward Earthquake Scenario											
Upper	0	1	1	0	0	0	0	1	1	3%	28%
Lower	5	22	27	1	0	1	6	22	28	88%	64%
High Pressure	1	2	3	0	0	0	1	2	3	9%	8%
Total (1)	**6**	**25**	**31**	**1**	**0**	**1**	**7**	**25**	**32**	**100%**	**100%**

Note:
(1) Totals may not add up correctly due to rounding.
(2) These columns show the number of failures and length of pipe by zone. It points out that while the Upper Zone has 28% of the system pipe, it only has 3% of pipe failures, and that the Lower Zone has 64% of the system pipe, but 88% of the failures.

The number of estimated failures is an approximation based on empirical data, and is intended to be used for planning purposes. The number of actual failures encountered may range from twice as many as those listed to half as many as those listed in the table.

The San Andreas scenario has three times the number of failures as does the Hayward scenario. The San Andreas fault is approximately 1 mile west of the western edge of the service area, where as the Hayward Fault is distant, across San Francisco Bay.

The large majority of failures are in the Lower Zone. The Lower Zone has the most pipe (64 percent of the system total), and the highest failure percentage (88 percent of pipes estimated to fail). This is the result of most of the Lower Zone being in High or Moderate Liquefiable soils, compared to the other pressure zones. The Upper Zone is closer to the San Andreas fault, but wave propagation is less damaging than the liquefaction in the Lower Zone.

The Upper Zone has only one estimated pipeline break, where the pipeline segment (GIS ID B16-PU-1256, 10-inch diameter AC) is shown to cross a liquefiable area. The soils along this pipeline should be investigated for liquefaction susceptibility. If they are liquefiable, the pipe should be replaced with ductile iron pipe with seismic joints. Otherwise, pipe damage in the Upper Zone is estimated to be limited.

The Lower Zone has an estimated 66 breaks and 18 leaks. All of the Lower Zone is in the moderate or high liquefaction zones where significant pipe damage is expected. The Lower Zone has no storage but is fed by three connections to the SFPUC. It is unlikely that the distribution system could deliver water to each of those breaks because of the hydraulic network limitations. That is, an 8-inch pipe attached directly to a 24-inch pipe will, if broken discharge a large volume of water. If that same broken 8-inch pipe is fed by a series of 6-inch and 8-inch pipelines in a grid, ultimately connected to a 24-inch line a mile away, the discharge rate would be much smaller. In addition, the breaks may result in loss of connectivity to section of the pressure zone.

To reduce the number of breaks, it is recommended that MPMW continue its pipeline replacement program, selecting the most vulnerable pipelines for replacement. The most vulnerable pipelines are in liquefiable soils by a wide margin, so Table 5 includes only pipe in liquefiable soils. Table 5 shows the pipeline footage that would require replacement to reduce the number of breaks prioritized by pipe material and liquefaction zone.

Table 5 prioritizes pipe replacement by Breaks/1,000 feet. In general, this correlates with: first – cast iron, and – AC and PVC both in highly liquefiable zones and second – cast iron and AC/PVC in moderately liquefiable zones, and third DIP in highly liquefiable zones. CIP has historically been highly vulnerable to both PGD and PGV/shaking. The cast iron is very brittle, and easily cracks under bending. The joints are typically leaded, and a very rigid. Even small movements will cause them to leak, and with larger movements cause the pipe bells to break and/or the joints to separate. The AC pipe barrel is moderately brittle and will break under moderate bending loads. AC pipe connections are flexible, essentially having two gasketed joints in each. The PVC pipe barrel is moderately rigid and will crack in bending or shear. PVC joints are relatively deep reducing the numbers of joints separation, but will not accommodate much rotation. The DIP barrel and joint are both ductile. The bell is shallower than a PVC joint allowing pullout in moderate PGDs. Approximately 80% of pipe failures in the Kobe Japan system in the 1995 earthquake were due to unrestrained joint ductile iron pipe joint separation. The K values assigned to these pipe types are consistent with the replacement priority.

However, because of the very high shaking intensities due to the proximity to the San Andreas Fault, it is recommended that over time all pipe be replaced, including that in soils that are not vulnerable to liquefaction such as those in the Upper Zone. Pipelines 12-inch and larger should be replaced first for pipe in this category.

Table 5. Prioritized pipe replacement by material and liquefaction zone. Pipe breaks for the San Andreas scenario						
Material	**K2**	**Liquefaction Zone**	**Length, ft**	**Number of Pipe Breaks due to Liquefaction**	**Breaks /1,000 ft**	**Replacement Priority (1)**
Cast Iron	1	High (2)	300	0.3	1.00	1
AC/PVC and Similar	0.8	High (2)	30,000	22	0.74	1
CIP	1	Moderate (2)	5,000	2	0.40 (2)	2
DIP (unrestrained)	0.5	High (2)	15,000	7	0.47 (3)	3
AC/PVC and Similar	0.8	Moderate (2)	103,000	31	0.30	2
DIP	0.5	Moderate (2)	56,000	11.0	0.20	4
Total/Ave			209,300	73.7	0.35	

Notes:

(1) Replacement Priority 1 is highest priority.

(2) The liquefaction zone designation and the associated PGD make a significant difference in prioritizing pipe. It is recommended that MPMW develop more precise liquefaction and PGD mapping. (See Table 8, recommendation No. 1)

(3) DIP in the High liquefaction zone and CIP in the Moderate Liquefaction zone are statistically close. It is recommended that the CIP be replaced before the DIP as it is older and likely has a shorter remaining life.

As shown in Table 5, the initial focus for pipe replacement should be on CIP, AC, PVC, and unknown pipe materials in the high liquefaction zone areas. For the San Andreas scenario, the pipelines with a repair rate greater than 0.59 per 1,000 feet (red on Figure 2) are the highest priority. Those with a repair rate of greater than 0.46 per 1,000 feet and up to and including 0.59 per 1,000 feet (orange on Figure 2) are the next highest priority. There are approximately 30,000 feet in the highest priority, and 20,000 feet in the next highest priority. CIP in the moderate liquefaction zone follows. Replacing CIP in the moderate liquefaction zone is preferred over replacing DIP in the High liquefaction zone because of other non-seismic reasons. Ultimately all unrestrained pipe should be replaced.

The 12-inch pipeline along Highway 84 is highly vulnerable, and is used to provide fire protection to a PG&E substation. The City should continue pursuing an alternate water supply for fire suppression in that area, or replace the line.

Prioritization is sensitive to the liquefaction zone probability of liquefying producing PGD, the PGD, and the K2 value. Further geotechnical work is recommended to enhance MPMW's understanding of the liquefiable areas. Further investigation is recommended to clarify MPMW's understanding on unknown pipe materials.

Table 6 shows the various conditions MPMW encounters and recommended pipe materials. Recommended pipe materials are organized by criticality, ground motion, liquefaction zone, PGD, and soil corrosivity. Criticality levels include high – backbone, transmission, large diameter; and moderate - smaller diameter residential/commercial. More reliable pipe is selected for high criticality demands.

Ground motion is a function of proximity to the San Andreas Fault; categories include very strong – PGV >24 in/sec, and strong <= 24 in/sec. The Upper Zone is subject to very strong ground motions.

High criticality pipe is expected to have the best performance in earthquakes. Recommendations for this pipe include: steel with butt welded joints, DIP with earthquake resistant joints, molecularly oriented PVC pipe (PVCO) with seismic restrained joints, and HDPE in soils with low corrosivity, eliminating the steel and DIP options in corrosive soils. All of these pipe systems are designed to accommodate 1 percent strain without failure. Steel with butt welded joints and HDPE pipe will accommodate the 1 percent strain using the ductility of the pipe material. DIP pipe with earthquake resistant joints (ERDIP) accommodates the strain in the joint. ERDIP is available from three US, and one Japanese manufacturer. American and Kubota lead the four manufacturers as far as expected earthquake performance. PVCO can accommodate the strain using the pipe ductility and will accommodate further strain in the joint equipped with bolt harnesses.

All but one of these ERDIP pipe systems has been successfully tested at the seismic pipe lab at Cornell University. PVCO has successfully undergone extreme earthquake testing at the seismic pipe lab at Cornell University. PVC (AWWA C-900) pipe is inherently brittle and has been known for cracks to propagate the full length of the pipe in non-earthquake conditions. PVC was installed in Christchurch, New Zealand and subjected to the 2011 earthquake. It suffered significant damage which resulted in a decision to change of preferred pipe selection in liquefiable soils to HDPE or PVCO.

Moderate criticality pipe will be installed in the same seismic environments as high criticality pipe, but its reliability is less important. As a result, Steel with lap welded joints can be used. Butt welded joints develop the full strength of the pipe barrel whereas lap welded joints (welded on the outside) only develop about one-third of the strength of the pipe barrel. DIP with mechanically restrained joints (not wedges embedded in the gaskets) can be used in lieu of ERDIP pipe. PVCO pipe with double depth bells can be used in lieu of PVCO pipe with bolt harnesses for restraint. Double depth bells should provide adequate seismic resistance except for areas with extreme PGDs.

Table 6. Recommended pipe materials considering criticality, ground motion, liquefaction/PGD, and soil corrosivity						
Pressure Zone	**Criticality**	**Ground Motion**	**Liquefaction Zone**	**PGD**	**Corrosivity**	**Recommended Pipe System**
Upper Zone	High	Very Strong	None	None	Low	Steel with butt welded joints, DIP with earthquake resistant joints, PVCO with seismic restrained joints, HDPE
Upper Zone	Moderate	Very Strong	None	None	Low	Steel with lap welded joints, DIP with mechanical restrained joints (not wedges), PVCO with double depth bell, HDPE
Lower Zone	High	Strong	High	>4"	Low	Steel with butt welded joints, DIP with earthquake resistant joints, PVCO with seismic restrained joints, HDPE
Lower Zone	Moderate	Strong	High	>4"	Low	Steel with lap welded joints, DIP with mechanically joints, PVCO with double depth bell, HDPE
Lower Zone	High	Strong	High	>4"	Yes	PVCO with seismic restrained joints, HDPE
Lower Zone	Moderate	Strong	High	>4"	Yes	PVCO with seismic restrained joints, HDPE
Lower Zone	High	Strong	Moderate	<4"	Yes	PVCO with seismic restrained joints, HDPE
Lower Zone	Moderate	Strong	Moderate	<4"	Yes	PVCO with double depth bell, HDPE

Notes:

- Criticality: high – backbone, transmission, large diameter; moderate - smaller diameter residential/commercial. More reliable pipe is selected for high criticality demands.
- Ground motion: very strong – PGV >24 in/sec; strong <= 24 in/sec
- Earthquake resistant joints – restrained but allow longitudinal movement
- Mechanical restrained joints – requires locking ring, gaskets with wedges not allowed
- PVCO – Molecularly oriented PVC AWWA C-909
- Double depth bell – accommodates 2X extension before failure

In summary, it is recommended that MPWD maintain their pipe replacement program prioritizing on replacing pipe as follows:

(1) CIP, AC, and PVC in the high liquefaction zone
(2) CIP, AC, and PVC in the moderate liquefaction zone
(3) DIP (unrestrained) in the high liquefaction zones
(4) DIP in the moderate liquefaction zone.
(5) All pipe (except ERDIP pilot project) in the Upper Zone

The liquefaction zones should be better characterized as they influence the prioritization of pipe replacement.

6.0 Palo Alto Pipeline

The SFPUC Palo Alto Pipeline (PAP), ranging in diameter from 12- to 36-inches, delivers water from the SFPUC Bay Division 1 and 2 Pipelines and supplies water south from Redwood City to the cities of Menlo Park and Palo Alto and Stanford University. The Burgess PRV is supplied from the Palo Alto Pipeline. Information about the pipeline, and its leak and repair history is summarized from the SFPUC 2016 State of the Regional Water System Report (SFPUC 2016), prepared to report on progress in implementing the Water System Improvement Program.

The pipeline is 5.36 miles long. It is a welded steel pipeline with coal tar coating and lining. It was installed in 1938.

The PAP was not seismically upgraded during the SFPUC seismic upgrade program in the early 2000's. No inspection history was identified in the 2016 report. The next inspection is scheduled for October 2022.

The pipeline had 2 leaks in the 1960s, a major leak in Menlo Park in 1990, and a pinhole leak caused by corrosion pitting in 2014. In 1987, a major leak was caused by a cable contractor scoring 1000 feet of pipe with a wheel cutter, and the pipeline was repaired by welding rolled steel plates over the score. About 700 feet was relocated in Redwood City, along 5th Street for the CalTrain grade separation project and valves F40 and F45 installed in 1994. New connections were installed to the BDPL Nos. 1 and 2 in 2002, and a repair was made with a 2-inch Bonney Flange in 2014.

7.0 Earthquake Response and Recovery

7.1 Interaction with the Fire Department

Jon Johnson, Fire Marshal of the Menlo Park Fire District provided the following water system recommendations:

- Fire hydrants connected to each emergency well with emergency power
- Static water supply storage with Fire Department Connections (FDC) – strategically placed throughout City
- Policy for C900 pipe to be installed for all Water Underground mains
- Fuel storage and fuel transportation means to keep City water pumps generators running for several weeks
- Mobile pumps that can be placed in service within any service grid
- Storage tank at Bayfront Bedwell Park with a suction and pump to draw water from the bay for firefighting purposes
- Identified service grids with identified markers with earthquake valves/sectional control valves to prioritize water delivery

Ensure adequate emergency interties with other Cities

7.2 Post Earthquake Water Supply

Water for fire suppression, and for critical facilities such as hospitals is required immediately following the earthquake event. For fire suppression, most any water is usable. For critical facilities such as hospitals, potable water is required. In the first 24 hours, there is potential that potable water sources will not be available from the SFPUC system. It would be beneficial to have potable water available from a local supply.

Water in storage tanks may be available to provide water for fire suppression and for potable use in the short term. However, if the storage tank is connected to a vulnerable pipe distribution system, it can quickly drain unless it is quickly isolated. Even if it is quickly isolated, it will not last long if it is being widely used for potable water throughout the community. Well supplies should be available on an ongoing basis, but well capacity may be limited, particularly for fire suppression depending on the aquifer. However, wells are dependent on power for pumping, so they should be fitted with an emergency generator. Well production capacity is also vulnerable to earthquake shaking and liquefaction lateral spread. Both storage tanks and wells may be structurally vulnerable but the vulnerability can be mitigated.

Pumping from San Francisco Bay with floating pumps may be viable for water for fire suppression. It may be difficult to permit fixed facilities such as dry hydrants. Tank trucks are capable of moving water from other sources, but they have limited capacity (e.g. 3,000 gallons), may be impaired by transportation system damage/gridlock, and will take time to deploy them.

Table 7 summarizes the features of each supply.

Table 7. Features of Alternative Water Supplies Following Earthquake

Alternative Supply	Immediate Capacity	Long-term Capacity	Potable	Fire Suppression	Structurally Vulnerable (1)	Aquifer Vulnerable (2)
Storage	X		X	X	X	
Wells	X	X	X	X	X	X
Pump from SF Bay	X	X		X		
Tank Truck	For Fire	Expensive	X	X		

Notes:
(1) Structural vulnerabilities can be mitigated
(2) Aquifer vulnerabilities are unknown and can't be mitigated

MPMW has installed one well and has plans for installing up to two additional wells to meet this immediate post-earthquake need. The aquifer could be vulnerable to earthquakes as they could change the aquifer's and well screen's hydraulic characteristics. In the extreme case, the well may not produce water after the earthquake. While this vulnerability is difficult to identify, considering past earthquakes, it is unlikely. Otherwise, this alternative wells meet all of the post-earthquake objectives. Therefore, MPMW's current program should continue to be implemented.

7.3 Emergency Response and Recovery

MPMW has an Emergency Response Plan, prepared in 2009, but should have an earthquake annex. It should also have an Earthquake Recovery Plan. The Emergency Response Plan is intended to provide direction to MPMW in the short term until the situation is stabilized. It should be all-hazards based with hazard-specific appendices. Depending on the earthquake this could range from a few hours to a week. MPMW should further develop their Emergency Response Plan.

Once stabilized MPMW will proceed to the Recovery phase. Facilities and pipelines are damaged and must be repaired. The Recovery Plan should include information on the likely damage to the system, and the strategy that should be employed to recover in an optimal manner. MPMW should develop a Recovery Plan.

8.0 Summary of Recommendations and Associated Cost

Recommendations are summarized in Table 8 along with their associated costs. Table 8 includes both recommendations from the 2004 study as well as new or updated recommendations.

Table 8. Recommendations including carryover from the 2004 report and updated from this report

Priority	No.	No. (from 2004)	Recommendation from 2004 Vulnerability Assessment	Comments	Estimated Cost
Medium	1	1	Perform a more comprehensive hazard review, including field survey of geologic conditions along critical pipeline alignments, review of boreholes, update of liquefaction and landslide models.	ABAG liquefaction mapping used for pipeline analysis for this report but does not provide the level of detail required to assess the pipeline replacement program	$50,000
Medium	2	2.1	Update pipeline analysis for updated hazards assessment.	It should be further updated following the detailed hazard review	$20,000
Very High	3	2.2	Establish pipeline replacement program. Prioritize pipe replacement based on hazard environment and diameter	An updated pipeline replacement program is being developed as part of the Water Master Plan.	$1,200,000/year
Very High	4	2.3.1	Conduct a detailed evaluation of the Sand Hill Reservoir Roofs. Perform a benefit cost analysis of retrofit recommendations, and refine the SIP budget	Roof/diaphragm seismic analysis is recommended. Geotechnical assessment of steep slopes surrounding the reservoirs is recommended ed. See section 4.1 of the report.	$60,000
Medium	5	2.3.4	Conduct a detailed evaluation of the Maintenance Building. Perform a benefit cost analysis of retrofit recommendations, and refine the SIP budget	Recommended - while light steel frame buildings are not likely collapse hazards, damage could result in red-tagging after an earthquake making them inaccessible.	$20,000
Very High	6	6	Implement non-structural anchorage program	A non-structural anchorage program should be undertaken as part of the maintenance budget.	$10,000/year for 2 years
Very High	7	7.1	Develop post-earthquake operational (annex to emergency plan) and recovery plans	Understanding the likely damage and a general approach to responding to the damage is important	40,000
High	8	7.2	Acquire emergency generators and portable pumps	Dependent on operational and recovery plans	As required by the operational and recovery plans

Table 8. Recommendations including carryover from the 2004 report and updated from this report

Priority	No.	No. (from 2004)	Recommendation from 2004 Vulnerability Assessment	Comments	Estimated Cost
Very High	9	NA	Develop and plan and acquire required equipment for fueling emergency generators following an earthquake	Fuel delivery is critical to keep generators functioning. Normal refueling procedures may not be available following an earthquake.	
Ongoing	10	8	Install wells for emergency use	Continue implementation of the Emergency Water Supply Program by construction additional wells.	Included in existing SIP
Medium	11	9	Develop a seismic design procedure manual for new pipelines and tanks	ASCE is developing a Manual of Practice for Seismic Design of Water and Sewer Pipelines. Adoption of this document may fulfill this recommendation. Menlo Park designs very few new tanks. It is recommended the seismic design criteria be reviewed for each new tank. This may fulfill this recommendation when complete.	0
High*	12	10	Upgrade wood roofs on Sand Hill Reservoirs. Implement geotechnical mitigation.	Upgrade wood roofs on Sand Hill Reservoirs. Implement geotechnical mitigation. (see 2.3.1 above). Dependent on assessment findings.	$3,000,000

* Depends on results of the detailed evaluation of the reservoirs (recommendation 4).

9.0 References

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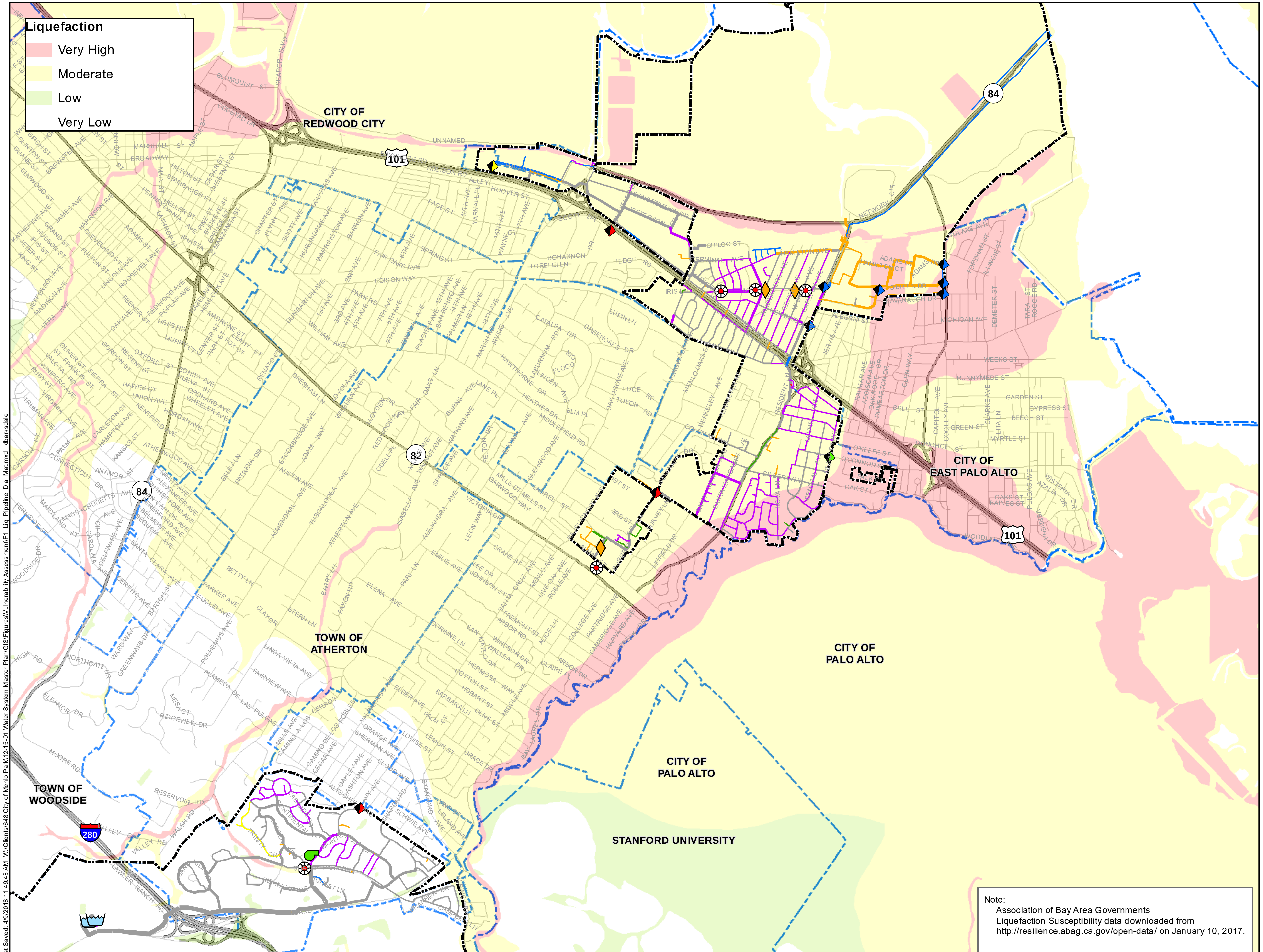
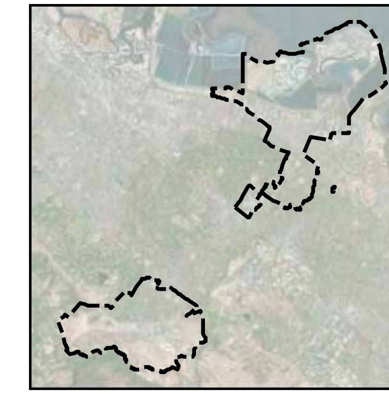
U.S. Geological Survey. ShakeMaps. Accessed at: https://earthquake.usgs.gov/data/shakemap/





0 1,500 3,000
Scale in Feet

Sand Hill Reservoirs
Sharon Heights Pump Station
Pressure Reducing Valve Station
SFPUC Turnout
Water Service Area Boundary

Emergency Interconnections

CalWater
City of East Palo
City of Redwood City
O'Connor

Material

AC
CI
DI
ERDI
HDPE; PVC
STEEL
Unknown

Diameter (size only)

14-inch or larger
10-inch & 12-inch
8-inch or less

CITY OF MENLO PARK
WEST YOST ASSOCIATES

Figure 1

Liquefaction, Pipelines and Facilities

Menlo Park Municipal Water
Water System Master Plan

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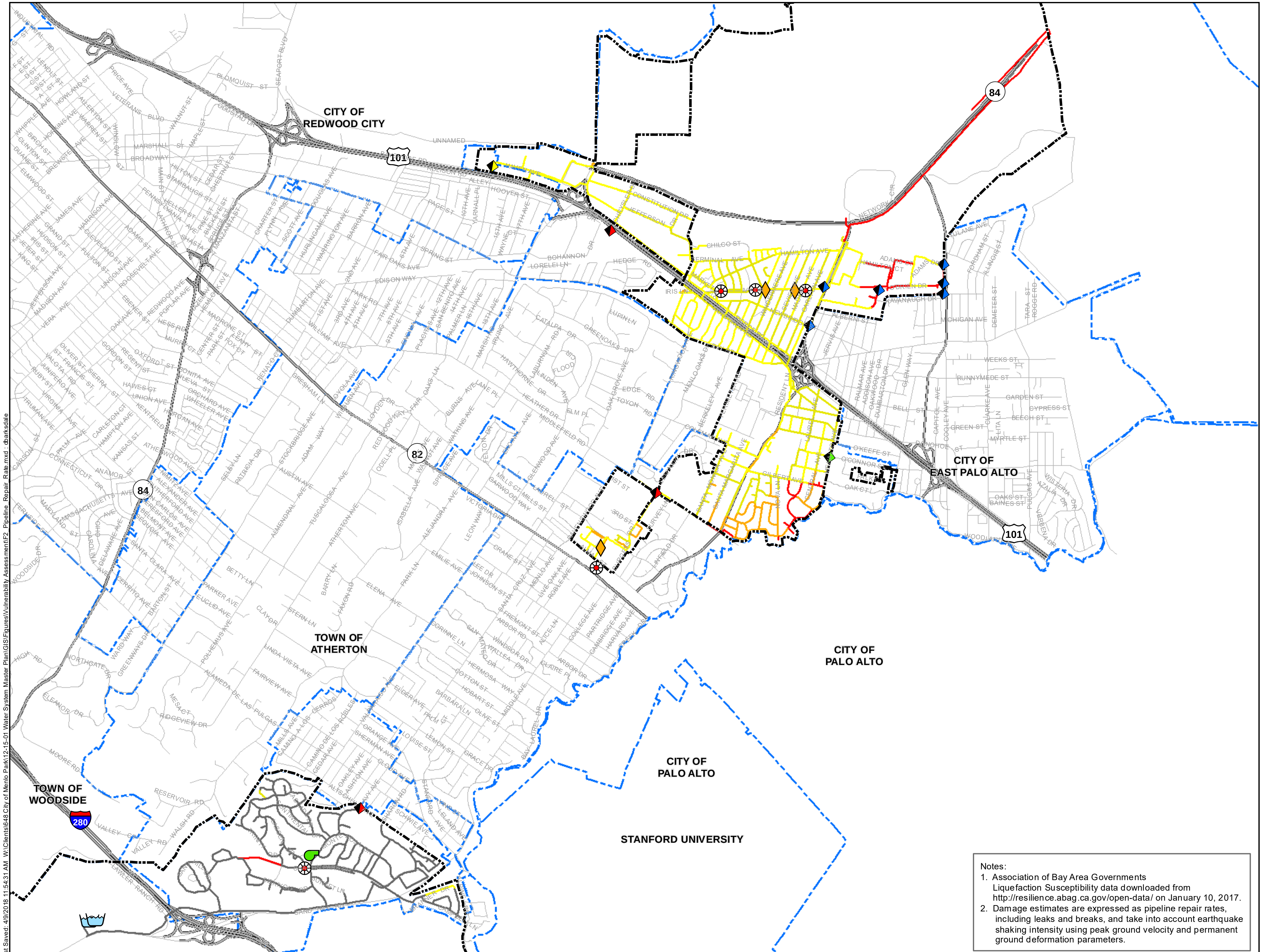

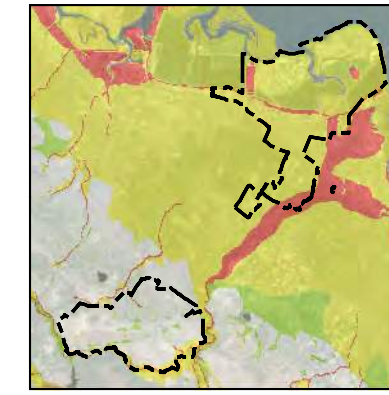

0 1,500 3,000
Scale in Feet

- Sand Hill Reservoirs
- Sharon Heights Pump Station
- Pressure Reducing Valve
- SFPUC Turnout

Emergency Interconnections

- Cal Water
- City of East Palo
- City of Redwood City
- O'Connor Tract Co-Operative Water Co.
- Water Service Area Boundary

Leaks and Breaks per 1,000 feet

- Less than 0.1
- 0.10≥X≤0.11
- 0.11>X≤0.13
- 0.13>X≤0.36
- 0.36>X≤0.46
- 0.46>X≤0.59
- Greater than 0.59

Notes:
1. Association of Bay Area Governments Liquefaction Susceptibility data downloaded from http://resilience.abag.ca.gov/open-data/ on January 10, 2017.
2. Damage estimates are expressed as pipeline repair rates, including leaks and breaks, and take into account earthquake shaking intensity using peak ground velocity and permanent ground deformation parameters.

CITY OF MENLO PARK

WEST YOST ASSOCIATES

Figure 2

San Andreas Liquefaction Pipeline Leaks and Breaks per 1,000 feet of pipe

Menlo Park Municipal Water
Water System Master Plan

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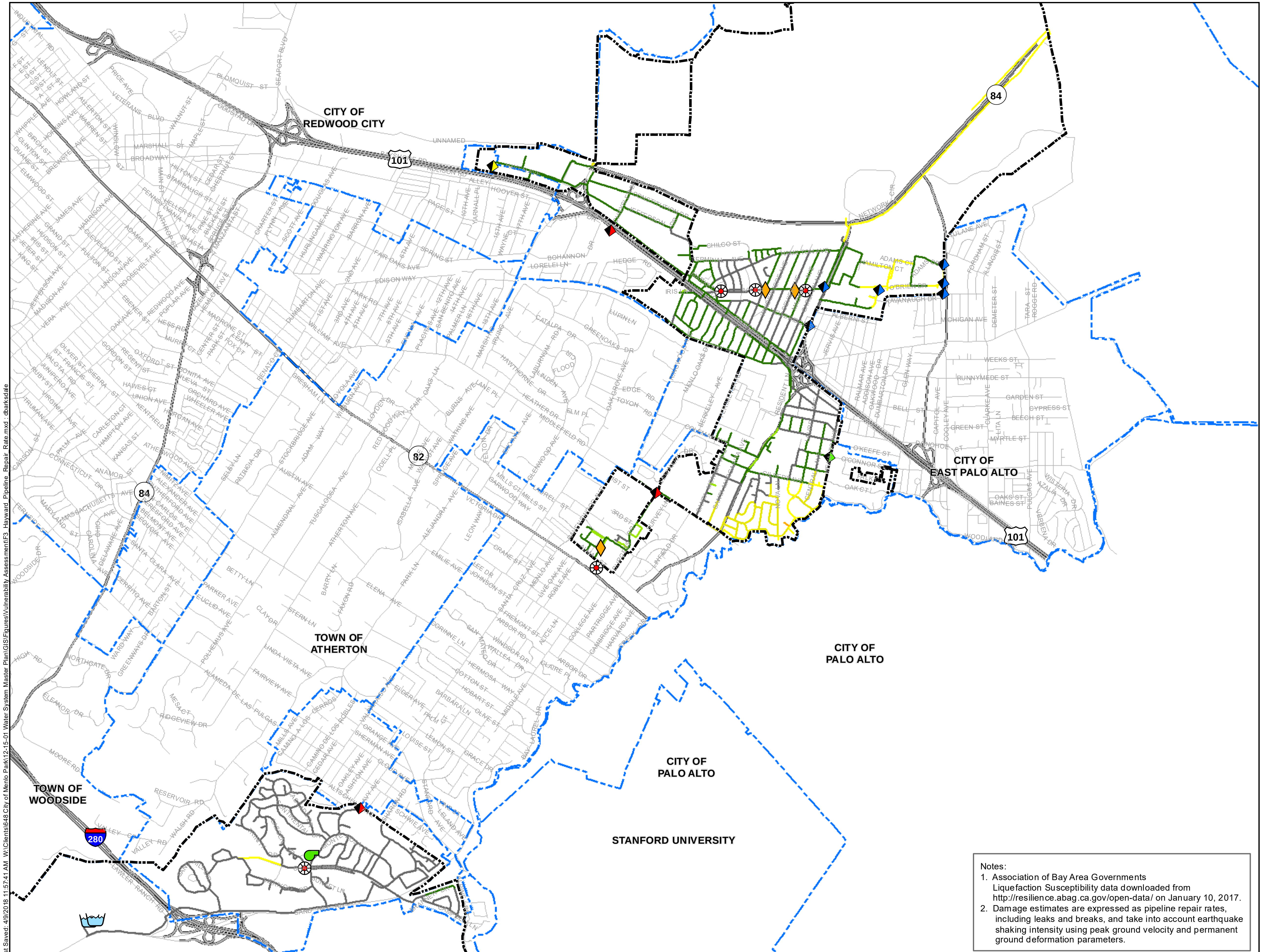
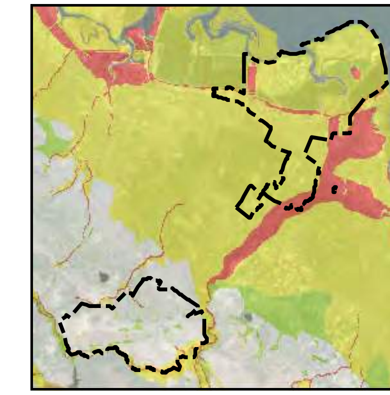


Notes:
1. Association of Bay Area Governments Liquefaction Susceptibility data downloaded from http://resilience.abag.ca.gov/open-data/ on January 10, 2017.
2. Damage estimates are expressed as pipeline repair rates, including leaks and breaks, and take into account earthquake shaking intensity using peak ground velocity and permanent ground deformation parameters.



N

0 1,500 3,000
Scale in Feet

- Sand Hill Reservoirs
- Sharon Heights Pump Station
- Pressure Reducing Station
- SFPUC Turnout
- Water Service Area Boundary

Emergency Interconnections
- Cal Water
- City of East Palo
- City of Redwood City
- O'Connor Tract Co-Operative Water Co.

Leaks and Breaks per 1,000 feet
- Less than 0.1
- 0.10≥X≤0.11
- 0.11>X≤0.13
- 0.13>X≤0.36
- 0.36>X≤0.46
- 0.46>X≤0.59
- Greater than 0.59

CITY OF MENLO PARK   WEST YOST ASSOCIATES

Figure 3

Hayward Liquefaction Pipeline Leaks and Breaks per 1,000 feet of pipe

Menlo Park Municipal Water
Water System Master Plan

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APPENDIX D

Advanced Metering Infrastructure Evaluation
Draft Technical Memorandum, September 27, 2017

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TECHNICAL MEMORANDUM

DATE: February 21, 2018 Project No.: 648-12-15-01

TO: Azalea Mitch, City of Menlo Park

FROM: Courtney Hall, PE, RCE #C85641
Roberto Vera, PE, RCE #C83500

REVIEWED BY: Ty Tadano, PE, RCE #C66147

SUBJECT: Advanced Metering Infrastructure Evaluation

INTRODUCTION

Menlo Park Municipal Water (MPMW) is considering changing its water meter system from manual meter readers by a private company to an Automatic Meter Reading (AMR) or Advanced Metering Infrastructure (AMI) system. As part of the Water System Master Plan, MPMW has requested that West Yost Associates (West Yost) summarize and evaluate AMR and AMI options.

This Technical Memorandum (TM) evaluates the infrastructure requirements, automated capabilities, operations and staffing requirements, and costs of AMR and AMI. This information is presented in the following sections:

- Purpose and Background
- Overview of Technologies
- Infrastructure Requirements
- Operation and Staffing
- Data Applications
- Costs
- Other Utility Experiences

PURPOSE AND BACKGROUND

AMR and AMI are applications of technology to automatically collect data from water meters. These technologies can use either use touch read or radio frequency communications to collect meter data for enhanced analysis and billing efficiency. AMR and AMI can be configured to allow handheld, vehicle-based, or fixed network infrastructure for meter data collection. MPMW is interested in investigating AMR and AMI metering technologies for the following key reasons:

- MPMW currently contracts with a third party for water meter reading, billing, and customer service. Meter reads are conducted once per month through a manual read of each meter. It may be beneficial to MPMW to have control, ownership, and management of this meter data in-house.
- AMR and AMI will decrease the time for meter data collection and improve the efficiency of billing operations. With AMR, other cities have found that a handheld AMR system requires approximately one-third the time of manual meter reads. AMR drive-by reads can be expected to take approximately 1 hour for a system the size of MPMW.
- AMR and AMI provide the opportunity for increased customer service through more accurate meter reads. Additionally, with the potential for adding customer-faced interfaced for the water use data, AMR and AMI will provide better communication to the customer regarding their water use trends and answers to their billing questions.
- AMI provides utilities with the opportunity to identify water usage trends in ways that are not achievable with monthly or bi-monthly meter reads. This allows utilities with AMI to proactively alert customers of potential leaks or high water usage.

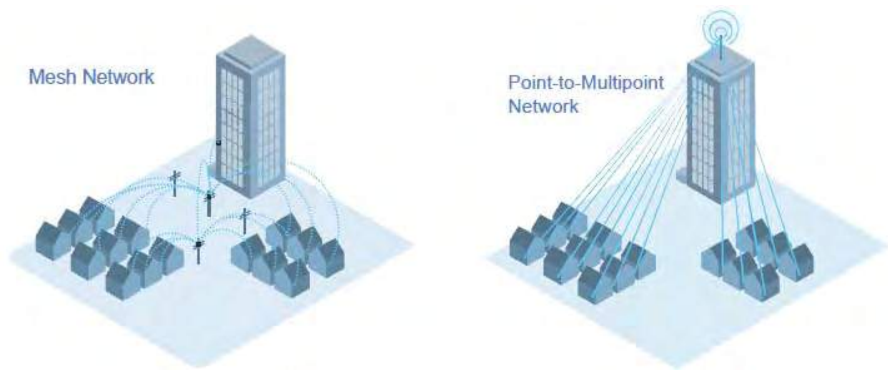
OVERVIEW OF TECHNOLOGIES

This section provides an overview of what AMR and AMI are and how these systems are configured. MPMW's existing water meter infrastructure has standardized on Sensus equipment. This evaluation is conducted with the assumption that due to MPMW's experience with Sensus products and the desire to ensure equipment compatibility, most of the existing Sensus meters will remain in use and other meters from other manufacturers will be replaced with Sensus products.

Communication Technology

Wireless communication for AMI and AMR can either occur through a mesh network or point-to-multipoint network, as shown on Figure 1. In a mesh network, the meter radios communicate with each other to transmit the data to the receiver. A mesh network uses public, unlicensed channels for communication. Interference from other devices such as cordless telephones, baby monitors, and wireless Internet access modems will occur. To combat this interference, utilities can install a larger number of receivers to shorten the distance between the meter and the receiver. In a point-to-multipoint network, the meter radios can communicate with the base station but not to each other. Point-to-multipoint networks use a private, licensed bandwidth range to communicate, and will not be subject to interference from other wireless devices. However, the availability of these licensed networks is limited and access must be purchased or leased. Sensus FlexNet network uses a licensed point-to-multipoint network.

Figure 1. AMI Network Configuration



Automatic Meter Reading

AMR uses radio frequency communication technology (i.e., Sensus RadioRead) or wireless reading probes (i.e., Sensus TouchRead) to read meters without requiring a physical read from the meter or entry into the meter box. With a RadioRead system, AMR meters can transmit data for a short distance through short-range radio frequency networks (Sensus uses the 433 MHz and 868 MHz frequency bands), which allows readings either by walk-by or drive-by AMR data collection devices. The meter reading is transmitted along with the unique identification number of the meter, which allows the utility to tie the reading back to the appropriate customer upon download of the data. In a two-way radio system, the data collection device transmits a signal to the meter instructing it to power-up and transmit the data. In a one-way radio system, the meter continuously transmits data, which is collected by the data collection device as it comes within range of the meter. A handheld unit can collect data from a short distance away, up to approximately 1,000 to 1,500 feet. A vehicle-based system uses a stronger radio signal than the handheld device and can read meters up to a mile away, depending on geography. The radio frequency used for AMR can be either a public frequency, similar to those used by baby monitors and other wireless devices, or it can be a private frequency that is reserved under federal law. Sensus uses a private frequency.

TouchRead is one type of AMR which uses a wireless reading probe and handheld device to collect a read from each meter as well as the unique identification number of the meter. With TouchRead, the meter reader still must go to the site of the meter and touch or place the wand in close proximity to the meter’s transceiver to collect the read. The reading data is later downloaded to a PC where it can be used to generate management reports or for printing customer bills. Speed and efficiency are increased by electronic reading and errors caused by incorrectly entering data are eliminated with both RadioRead and TouchRead AMR systems. AMR will increase the accuracy of meter reads when compared to manual reads, thus providing a more accurate billing to customers. Just like with manual reads, AMR typically has only one read per month per meter, which will not help the customer determine the cause of high consumption.

Advanced Metering Infrastructure

AMI is the networking technology that builds on the AMR infrastructure to use near real-time data to remotely monitor and manage the water utility infrastructure. This networking technology uses a fixed base for antennas that collect the radio reads from meters within a radius up to 5 miles from the base station using a longer-wave radio frequency. A data management system is used to store and interpret the large amounts of data collected from each meter. AMI helps utilities increase the efficiency of operations through automatic meter reading and remote connections and disconnections. Additionally, AMI has the added benefit of providing real-time data for the utility to use to detect leaks and manage demands. Sensus licensed radio spectrum ensures optimal base station performance, free from interference by other wireless services or radio devices. It also eliminates the risk of being taken over by emergency service providers.

AMI will increase the accuracy of meter reads when compared to manual reads, thus providing a more accurate billing to customers, and will also collect data more frequently than both AMR and manual reads. AMI can collect data in intervals as frequent as 15 minutes, which can be shared with the customer through an online interface to help them see trends in their water use to identify leaks or high water use activities.

INFRASTRUCTURE REQUIREMENTS

This section describes the equipment and software requirements for an AMR or AMI system.

Equipment

AMR/AMI system requirements include a meter to measure the volume of water demand, a register to record the water use, and a transceiver to transmit the meter read to the AMR or AMI device, all shown in Figure 2. During the Fall 2015 field verification conducted by West Yost, the size and model for each of the water meters was identified and recorded. In discussion with Craig Molaug from Golden State Flow Measurement, a representative for Sensus products, it was assumed that the existing Sensus C^2, OMNI, SR I, and SR II meters can continue to be used in an AMR or AMI configuration without the need for replacement at this time. These models comprise approximately 1,962 of the existing 4,355 water meters in the system. The remaining 2,393 meters may not be compatible with the chosen system and this evaluation assumes that they will need to be replaced. These meters are either older Sensus meters that are not compatible with AMR or AMI or the meters are from another brand (e.g., Badger, Neptune). Other manufacturers can provide similar equipment and services; however, compatibility with MPMW’s existing Sensus equipment will need to be evaluated on a case-by-case basis.

Figure 2. AMR and AMI Meter Equipment

AMR would require collection devices to provide communication with meters and collect and store meter data. These data collection devices can be configured as either TouchRead collection devices, handheld walk-by radio-frequency units, or vehicle base station drive-by radio-frequency systems. A handheld TouchRead system would include the equipment shown on Figure 3: a wand that transmits data from the meter (left) and a hand-held device to store the meter reads (right). MPMW has been installing TouchRead meters on commercial units and other high-flow users. A TouchRead system improves the accuracy and efficiency of collecting meter reads; however, a meter reader would still be needed to physically visit each meter, just as is currently done with the manual ready system.

Figure 3. AMR TouchRead Communication Equipment

A handheld walk-by radio-frequency unit would include the equipment shown on Figure 4: a hand-held device to communicate with the RadioRead transceivers and store the meter reads. The transceivers would transmit the meter reads a short distance (1,000 to 1,500 feet), which would limit the need for a meter reader to access every property and would eliminate the need to open the meter box to access the meter.

Figure 4. AMR Handheld RadioRead Communication Equipment

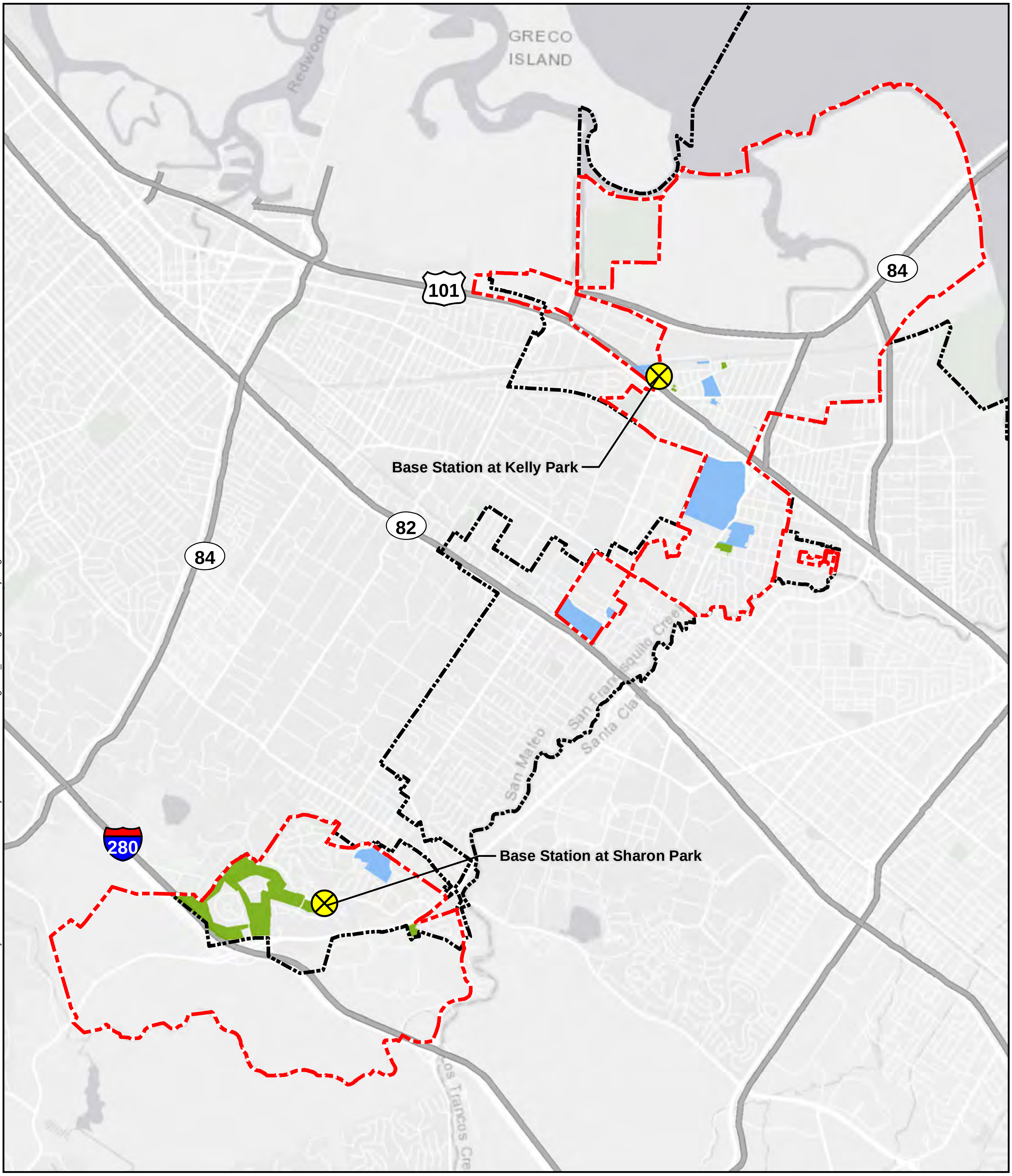
AMR can also be configured in a drive-by data collection format. Short-range radio frequencies are used to transmit meter reads to a vehicle base station within close proximity (1,000 to 1,500 feet). Vehicle base station system components include those shown on Figure 5: a radio-based communication unit, laptop with AMR data collection software, GPS antenna, and antenna (to be placed on the roof of the vehicle). Additionally, one hand-held device (shown in Figure 4) would be purchased for backup and field use with the vehicle base station set-up. A vehicle would need to be made available for the AMR data collection, which is expected to take approximately 1 hour to drive for MPMW's system. The AMR equipment is portable and can be removed from the vehicle to allow for full use of the vehicle for other purposes when not required for AMR.

Figure 5. AMR Vehicle Base Station Communication Equipment

AMI uses a longer-range radio frequency compared to AMR, which allows the signal to be transmitted longer distances, typically ¼ mile to 3 miles. The meters transmit data to a base station, which transmits the data to a centralized database for MPMW to use for billing or other analysis. The equipment required for AMI includes three main components: antenna, base station, and software. The antenna transmits data between the meter transceiver and the base station. Reception range can be increased by placing the antenna at the highest possible location (e.g., water tower, cell tower, tall building, or other elevated structure). The base station, shown on Figure 6, provides a link between the meter transceiver and the software. The base station would be located at the base of the structure used for the antenna mounting. The software manages the communication with the base stations and the meter transceivers, interfaces with the customer information/billing system, and serves as a data collection repository for the data collected by the system.

Figure 6. AMI Communication Equipment – Base Station

A propagation study would be used by the meter vendor to determine the location for required AMI equipment. Initial conversations with Craig Molaug from Golden State Flow Measurement, a representative for Sensus products, indicate that two base stations would likely be required for Menlo Park, one base station near Highway 101 to collect data on the east side of the city and another near Sharon Park to collect data from the west side. These proposed locations are shown on Figure 7. It is assumed that a suitable location for the base station could be found in one of the City's existing public facilities or parks.



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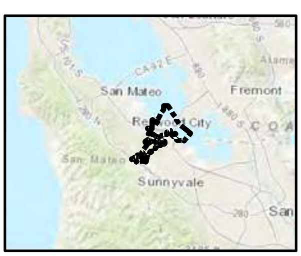

Symbology

- Water Service Boundary
- City Limits
- Parks & Recreation
- Public Facilities
- Proposed AMI Base Station

N

0 2,500 5,000

Scale in Feet

CITY OF MENLO PARK

WEST YOST ASSOCIATES

Figure 7

Proposed Base Station Locations

Menlo Park
Municipal Water
Water System Master Plan

Software

AMR would require a software that would automate the transfer of data between the meter reading device and MPMW's billing software. Sensus AutoRead® is a highly customizable software which uses the data collected from TouchRead and RadioRead systems to integrate into any billing software.

AMI requires a more powerful software that is able to analyze the large volume of data collected. Just like the software used with AMR, AMI software would integrate with billing software. In addition, the software would have analytical capabilities in order to help utilities make informed decisions. The software validates the data and uses the validated data to determine areas of high usage, suspected vacancies, and other anomalies. Some software is able to integrate with SCADA or GIS to provide a more detailed picture of the system operation. In addition to MPMW's platform, a customer portal can be added to some AMI software that allows customers to track their water use and set email notifications for suspected leaks. The Sensus® Logic Meter Data Management (MDM)™ provides these capabilities.

OPERATION AND STAFFING

This section outlines the operation and staffing requirements for AMR and AMI systems.

Operation

Many utilities with AMR or AMI have an online interface for customers to view their water use. Resolution of the water use data will vary based on the frequency of meter reads, up to hourly for AMI system and monthly for AMR systems. The online interface can help customers reduce water usage through identifying high water usage activities and detecting sources of leakage. However, both notifying customers of these high-usage events and handling the increase in customer calls following notification can put a strain on staff resources and can necessitate the hiring of an additional staff. Other utilities have found that one full time staff dedicated solely to customer service calls was necessary once they switched to AMI. The increase in customer service calls is not expected to be as significant with an AMR system. A customer typically only receives one data point per month with AMR, while the AMI system provides up to hourly data for customers to analyze.

A vehicle base station AMR system would require one person to drive the data collection route. This route would be established at a later date, but for a system the size of MPMW, it is expected that the established route will take approximately one hour to drive. One staff will need to complete this route once per month. A hand-held AMR system would reduce the time needed in the field for meter reading to approximately one-third the time that is currently required to complete manual reads.

Staffing

With the addition of radio communication equipment, including radio transceivers at each meter, maintenance needs will likely increase. Other cities have found that the communication between the meter transceiver and base station can fail for multiple reasons: cut/disconnected wire, signal blockage, etc. Maintenance staff will need time to learn the skills required to reprogram meters and otherwise troubleshoot the types of issues that are likely to occur with the radio communication equipment. Overall, other utilities have found no net change in the amount of maintenance staff time needed; the staff simply needed time to get familiar with troubleshooting the AMR and AMI communication issues.

If MPMW choses to install an AMR system, there would be staffing needs in collecting the data. For a vehicle-based system, one person would need to collect the data by driving throughout the system. The meters transmit the data over short distances, so the route would not need to include every street. For MPMW's system, a route that collects data for the entire system is expected to take approximately on hour to drive. If a TouchRead AMR system was chosen there would be no change to the staffing required, and MPMW would need to continue to contract with a meter reading service or dedicate additional City staff to this task. However, the TouchRead AMR system would take approximately one third the time of the current manual read system.

DATA APPLICATIONS

This section describes the data applications including usage statistics reporting and linking to GIS or SCADA.

Usage Statistics Reporting

AMI meter data management software has usage reporting built in to alert the utility to a variety of issues that may signal maintenance issues, communication issues, or other problems with the AMI system. The software can be set up to automatically send alerts to the utility about users with high water use, low/zero water use, suspected leaks, backflow conditions, and broken pipes. Additional alerts can be set for stale reads (latency > 10 days), orphan meters (radio not associated with a utility account), and other communications issues. These alerts help the utility identify and solve issues that would be unknown without AMI.

AMR does not provide additional data for usage statistics reporting compared to a manual read, assuming that reads are not taken more frequently. AMR's advantage over manual read is that it lessens the time needed in the field to physically read or touch each meter, and that misreads and other human errors are reduced.

Linking to GIS or SCADA

AMI data can be linked to GIS in order to reveal geographic trends in the data. Sensus® Logic MDM integrates with ESRI ArcGIS to display view of the network, which can be filtered based on the analytical data. Using a GIS-approach can help the operator schedule inspections of suspected issues based on location to save time. Additionally, GIS can help the operator connect multiple instances of backflow or other atypical data to the same problem such as a break in an adjacent water main or a fault in a common communication path. With the Sensus® Logic MDM™

suite of products, the GIS-integration capability can be added on at any time that MPMW determines would be beneficial.

SCADA integration creates a two-way communication between its system and the AMI system. SCADA water production values can be used in conjunction with water meter consumption data in real time to determine the location and quantify the size of potential system leaks. This integration of real-time consumption and operational data provides the utility a single platform for complex analysis and reporting.

COSTS

This section outlines the capital costs and recurring costs for AMR and AMI. A summary of the costs described in this section are shown in Table 1. The difference in equipment costs for implementing AMR versus AMI is relatively small – approximately 5.5 percent ($135,300). However, the annual costs for the AMI analytical software are higher than the AMR software support ($23,800 per year difference).

Table 1. Equipment Costs for AMR and AMI

Item	Units	Unit Cost, dollars	Capital Cost, dollars	Annual Subscription Cost, dollars/year [(a)]
Automatic Meter Reading (AMR)				
Meter	2,393	200	478,600	-
Register	2,393	70	167,510	-
Transceiver Unit	4,355	145	631,475	-
Installation (per meter location)[(b)]	4,355	115	500,825	-
Handheld RadioRead	1	9,000	9,000	-
Vehicle Base Station	1	20,000	20,000	-
AutoRead Software	1	17,000	17,000	1,200
Customized GIS Integration	1	2,500	2,500	
Misc. Pipeline/Water Service Improvements[(c)]	600	500	300,000	
		Subtotal	**2,126,910**	**1,200**
		Contingency (30%)	638,073	**-**
		Total	**2,764,893**	**1,200**
Advanced Metering Infrastructure (AMI)				
Meter	2,393	200	478,600	-
Register	2,393	70	167,510	-
Transceiver Unit	4,355	145	631,475	-
Installation (per meter location) [(b)]	4,355	115	500,825	
Base Station	2	50,000	100,000	-
Sensus Analytics Software	1	50,000	50,000	20,000
Sensus Analytics Customer Add-On	1	0	0	5,000
Customized GIS Integration	1	2,500	2,500	
Misc. Pipeline/Water Service Improvements[(c)]	600	500	300,000	
		Subtotal	**2,230,910**	**25,000**
		Contingency (30%)	669,273	**-**
		Total	**2,900,183**	**25,000**

Sources: Costs were provided by local representatives of Golden State Flow Measurement and Sensus.

(a) Annual costs shown do not include equipment maintenance.

(b) Installation costs include contractor overhead and profit.

(c) It was assumed that 25 percent of the remaining 2,393 customer locations (or about 600 locations) would need miscellaneous pipeline or other water service improvements.

Equipment Costs

Equipment costs for both AMI and AMR include a AMR/AMI-compatible meter and register, as well as a transceiver unit for wireless communication. Approximately 50 percent of the MPMW system's meter and registers are currently AMR/AMI-compatible (Sensus SR I/SR II/OMNI/C^2 models) and would only require the addition of a transceiver unit. Sensus manufactures both single-port and dual-port transceivers. Both are approximately the same cost ($145 to $155), and installation of the dual-port system where two meters are in close proximity would provide a cost savings opportunity. For this planning-level cost estimate it is conservatively assumed that MPMW will use only single-port transceivers.

AMR would have different equipment requirements for data collection depending on whether MPMW chose to implement a walk-by or drive-by system. For this planning-level cost estimate, it is assumed that a drive-by system is chosen. The drive-by AMR vehicle base station would be the main unit used to collect data. One handheld RadioRead unit would be used by field crews to collect missed reads, confirm communication during maintenance and installation, and provide backup to the vehicle base station. If a walk-by system was chosen instead, the vehicle base station would not be required and would instead be replaced with a second handheld RadioRead unit. The vehicle base station would include the radio, antenna, and laptop. The handheld units include the unit, wireless interface, and chargers.

AMI would require installation of base stations to collect the meter data. Currently, the Sensus representative estimates that two base stations would be required for MPMW. Costs include materials and installation.

Each system would require a software purchase to integrate the meter reads with current billing software and, for AMI, to provide additional analytical capabilities. The AutoRead software for AMR only includes the ability to integrate meter reads with the billing software. The AMI Analytics software include the billing integration, analytics, and reporting. A customer interface platform can be added on to the AMI Analytics software for an additional annual subscription cost. This online platform would allow customers to view their water use and set their own alerts.

Recurring Costs

The software has an annual maintenance cost to cover upgrades to the system and hosting of the data. This annual maintenance cost is $1,200 for AMR and $20,000 for AMI, plus an optional $5,000 for a customer add-on to the AMI software. Batteries in the meters are guaranteed to last 20 years. If any battery fails prior to 20 years, it will be replaced at no cost to MPMW by the manufacturer.

Potential additional costs to MPMW may include additional staff time for data management, billing, and customer service. These types of costs are hard to predict and vary from one agency to another.

Contingency

A planning-level estimating contingency of 30 percent has been used to account for areas of uncertainty in the equipment and installation estimates. This contingency does not cover changes in scope for the contractor that arise due to field conditions upon installation of the meters. Some cities with older infrastructure have had issues with service lines requiring repair or other miscellaneous repair items during the process of replacing the water meter. To best understand these risks, MPMW could conduct a pilot test first across the service area. This would help identify the frequency and severity of repairs that will need to be made during the course of the meter replacements, and therefore, help refine the expected costs for an AMR or AMI project.

Phasing

For this cost estimate, it is assumed that the MPMW will hire a contractor to complete the meter installations. The contractor should install all meters in one phase. A single phase will be more cost-effective due to economies of scale as well as reduced mobilization costs from a single phase instead of repeated mobilization efforts. If MPMW determines that it is able to complete the meter installation in-house, it may be more beneficial to split the project into multiple phases. The size and timing of these phases should be created based on the availability of existing staff. Phase I should include the high water users so that larger leaks can be detected earlier and resolved. Subsequent phases should include the lower water use commercial and industrial meters and all residential meters.

OTHER UTILITY EXPERIENCES

As part of the AMR and AMI evaluation, West Yost contacted other municipalities that have recently implemented AMR or AMI. The experience of each municipality was unique, yet each had in common the following three main reasons for transitioning to AMR or AMI: improve customer service, improve the process for water billing, and improve water use monitoring. This section describes the experiences of the Cities of Redwood City, San Bruno, Ceres, Sacramento, and Woodland. A detailed record of the conversations is included as Attachment A.

City of Redwood City

West Yost spoke with Justin Chapel, Public Works Superintendent for the City of Redwood City (Redwood City) to learn about their transition to an AMI system. Redwood City first installed AMI for their irrigation system in 2008 and have since been expanding to the rest of their system. Redwood City chose to gradually convert to AMI for three main reasons: 1) meters won't require end-of-life replacement at the same time, 2) in-house staff can be used to convert each unit to AMI, and 3) to avoid the possibility of getting all meters or batteries from the same manufacturing batch which may have material or manufacturing defects.

Currently 60 percent of the system is on AMI and the rest of the system is on a TouchRead system. Sensus AMI was chosen since most of their meters at that time were Sensus and the ability for different manufacturer's products to communicate with each other was limited at that time. Redwood City has found that maintenance requirements for the AMI meters and transceivers has been higher than expected. When errors occur, it takes longer for the maintenance staff to troubleshoot the error and determine the cause. Read errors can occur due to physical blockage of the signal due to cars, incorrectly installed transceivers, cut/disconnected wires, programming errors, and billing-system data entry errors. Additionally, Redwood City installed some of the early models of the iPERL® electromagnetic pulse meter, which had issues with sealing and failed due to water getting inside the electronic portion of the meter.

City of San Bruno

West Yost spoke with Jim Burch, Deputy Director of Public Services – Maintenance and Operations for the City of San Bruno (San Bruno), to hear about their successes and issues moving to AMI. San Bruno started installation of the AMI system in July 2015 and Phase I was completed in May 2016. Phase I including the installation of over 10,000 residential meters, installation of the AMI base stations, and full integration with the billing software. Phase II will include replacing the TouchRead system used for approximately 900 commercial customers. San Bruno chose the Sensus AMI system since they already had the Sensus TouchRead system and were looking for an AMI that was compatible with their existing equipment. Additionally, the Sensus AMI communication network seemed to be more reliable since it uses a dedicated, private radio frequency, while the competitors use a public radio frequency that is more susceptible to interference.

San Bruno has seen a substantial increase in efficiency of billing and customer service following the installation of AMI. Billing was previously on a two-month cycle and staff were unable to help customers identify reasons for high water use since they only had one data point each month. With the hourly data that is now available to the customers online, they can identify high water use events on their own or San Bruno staff can pull up the data and share it with the customer when they come to City Hall to dispute a bill.

San Bruno and the contractor hired to install the new meters ran into many unexpected issues during installation. The biggest contributor to these issues was that the existing meters and infrastructure were 40 to 50 years old. Due to the age of the materials, replacement caused multiple breaks in the curb stops and private services. Additionally, many of the meter boxes were full of dirt, which San Bruno staff cleared ahead of the contractor to help keep the project from falling further behind. San Bruno also has many older homes that had the electricity grounded to the water main, which caused the Sensus iPERL® electromagnetic pulse flow meters to malfunction. Other than these issues during installation, San Bruno has not had any maintenance concerns with the AMI system. The biggest transition for the maintenance team has been learning how to troubleshoot and program meters when they have read errors.

San Bruno held meetings with all the internal stakeholders early in the process, which allowed the staff to have their concerns addressed upfront and early in the process. The integration with the billing software was completed very successfully due in large part to these key conversations. Jim found that the software integration process can be easily overlooked as utilities focus on the physical infrastructure needs, but he found that the focus on the software was equally instrumental in San Bruno's success.

City of Ceres

West Yost spoke with Jeremy Damas, Public Works Director for the City of Ceres (Ceres), to understand their experience with transitioning to an AMI system. Ceres transitioned from a flat-rate residential billing system with no meters and a TouchRead commercial metering system to AMI 2011. While initially only planning on transitioning to an AMR system, Ceres chose to go to a full AMI system due to direction from City Council. Sensus FlexNet was the selected AMI system, and Ceres has had no issues with radio communication. The reporting within the MDM system has not worked for Ceres, so they have had to create their own custom reports to identify issues such as high usage, zero flows, and meter communication problems. Ceres had to replace the Sensus SR-II meters with Badger meters due to the large number of errors with the Sensus meters including leaking, knocking, mechanical failures, and communication failures. The Badger meters have been very easy to integrate with the Sensus FlexNet system and have solved most of the meter issues that Ceres had previously faced. Additionally, failures have been caused by the installation of a dual port radio system, which was done at the recommendation of the manufacturer. Most of the dual ports have now been removed.

Ceres created a customized online customer portal, since the commercial Sensus customer portal was not available at the time of their AMI installation. The customer portal shows hourly, daily, monthly, and annual consumption data and allows the user to set customized alerts to be sent via email or text once a pre-set water usage threshold is reached or for suspected leaks. Only 12 percent of the customers have set up an account. Customers are provided with leak alerts and high consumption alerts by Ceres staff, which, combined with the data available on the customer portal, results in a high volume of calls to Public Works. Ceres hired one additional full-time staff to handle the increase in customer calls.

City of Sacramento

West Yost spoke with Jon Conover, Meter Shop Supervisor for the City of Sacramento (Sacramento), to hear about their experience with AMR and AMI. Sacramento first installed a drive-by AMR system in the early 2000s. During the time that it was in place, the City used two different Badger platforms and did not have any major issues. However, in 2009 the City chose to transition to AMI as it provided an opportunity for increased customer service. Datamatic (now Zenner) was originally chosen for the AMI system. The City had numerous issues with the Datamatic meters, and were replacing hundreds of meters every month. Due to the ongoing maintenance issues, Sacramento switched back to Badger in 2014. Both Aclara and Badger were evaluated, and Badger was chosen due to better features than Aclara, as well as Sacramento's perception that Badger was focused on continuous improvement to their AMI products. Sacramento has been very happy with the Badger AMI system performance, and have seen a very low failure rate with the new Badger meters (less than one percent of the meters have failed).

Sacramento implemented an online customer interface for customers to view their water use and set water-use alerts. Additionally, Sacramento has recently started notifying customers about potential leaks that are detected through some of the reporting capabilities in the AMI software. While this has caused an increase in workload for the meter staff, the current staff have been able to handle the increased customer service needs.

Jon recommends testing multiple meters, if possible prior to installing a new AMR or AMI system. Following extensive testing, Sacramento chose to replace all electromagnetic pulse meters (also called “no moving parts” meters) that had been installed and replace with positive displacement meters. At this time, AWWA does not have a standard for electromagnetic pulse meters, and Jon found that none of the meters, regardless of manufacturer, are able to provide consistent, accurate flow measurement. Sacramento is currently testing meters that transmit data through cellular communication rather than radio frequencies and have had positive results getting reads from areas that are typically harder to read by radio, such as parking garages and basements.

City of Woodland

West Yost spoke with Jeremy Cox, Water Systems Administrator for the City of Woodland (Woodland), to better understand the transition to AMI. Woodland began implementing AMI in 2010, installing meters throughout the system which was previously on a flat-rate billing structure for all residential customers. The transition to AMI had hurdles that Jeremy would not expect with a system that is currently metered by a TouchRead or manual read system. These issues include finding multiple meters per property and difficulties matching the correct meter to each customer in the billing software. To ease the transition, Woodland chose to send a sample bill to customers for the first 6 months following meter installation. This allowed customers to review their water use, make adjustments to their water use, and fix leaks prior to getting their first bill under the new AMI system.

Woodland only installed new meters where they were needed, and kept existing meters where possible. In retrofitting these meters to AMI use, Woodland has found that meters from the same manufacturer of the AMI base stations have the fewest number of communication and maintenance issues. Additionally, older registers may not have the ability to be programmed to the 1 cubic foot per second level of accuracy needed for AMI. Older meters will contain higher levels of lead than newer meters, so Woodland has chosen not to repair any pre-2010 meters. Woodland has been installing the Sensus iPERL® and have been very happy with the performance and low-maintenance needs of electromagnetic meters compared to positive displacement meters.

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ATTACHMENT A

Other Utility Experiences Questionnaire

- City of Redwood City
- City of San Bruno
- City of Ceres
- City of Sacramento
- City of Woodland

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City of Redwood City – Justin Chapel, Public Works Superintendent, 650-780-7469

How long have you had AMR/AMI? What factors influenced your decision to go to AMR/AMI?

AMI was first installed in 2008, and was initially purchased for irrigation but has been expanding to the rest of the system. About 60 percent of system on AMI.

Which supplier/manufacturer do you use? Why did you select that company? What other metering systems did you consider?

Sole source to Sensus since Sensus was the manufacturer of most of the meters in Redwood City at the time (almost 100 percent of meters in City are Sensus now). Additionally, in 2008 there wasn't as much ability to communicate between meters of different manufacturers. The City uses the Sensus FlexNet network, which operates on licensed frequencies (2-watt output). They have three tower collectors and two repeaters. Repeaters are used in low-communication areas (i.e., canyons). For the first 3 to 4 years, only two towers were installed. There was a large hassle with permitting to get the third tower installed, so the City mounted the antenna on a water tower which is only about 25 feet above ground level. Despite not being very high, the communication between Redwood Shores and new tower has been very good.

What did you have before AMR/AMI?

Some routes were TouchRead, a majority was manual read, and drive by read in Emerald Hills (approximately 1000 meters). Drive by systems failed, so it was recently converted to AMI. The City chose to gradually covert to AMI for three main reasons: 1) All meters won't require end-of-life replacement at the same time, 2) in-house staff can be used to convert each unit to AMI, and 3) the City hopes to avoid batch issues with meters or batteries.

How has the maintenance compared to what you expected? More time/less time?

The AMI system has required more maintenance than expected. More time is spent troubleshooting when a reading doesn't occur. Reading errors can occur due to typos in the meter number, car blocking signal, incorrectly installed meter/radio, cut wire from register to radio, programming error, etc.

MDM System alerts City to maintenance needs and potential issues. Alerts include stale read (latency of >10 days), orphan meter (radio activated not associated with utility account), leaks, high usage, reverse flow, and broken pipes. The no flow/high flow alerts helped them identify some issues with the Sensus iPERL® electromagnetic pulse meter. Early models were not sealing properly and water was causing the electronic portion to get wet and malfunction. The City was also able to identify cross-connections to private irrigation wells due to the backflow alerts. All alerts go to the City, expect leaks which go directly to the customer. The MDM system also has a lot of built in tools that the City uses to troubleshoot data prior to sending to billing.

Have you seen a reduction in operating cost in the field and/or office?

The City has found that it takes longer to review readings prior to sending to Billing since all touch-read are now on same route. About 0.8 percent of the readings don't go through, so these reads have to be redone manually. The City want readings on specific day for Billing, so will send someone out to gather data unless data is available within two days of the set day. The City is still working on automation of the data processing/billing. The biggest reason the City has had for not getting a reading is data entry on the billing system or mechanical issue with meter/radio.

For AMI utilities – Have you integrated the AMI software with any other interfaces (SCADA/GIS/etc.)

There is no direct integration with the AMI system, but GIS is integrated with WO system to show map of meter location when a work order is created to fix a meter reading error.

For AMI utilities – Do your customers use the AMI capabilities such as real-time consumption monitoring?

City created WaterPortal, a customized in-house customer web interface, so that irrigation customers can track water use versus daily allocation. All customers can view total water consumption, daily consumption, and hourly consumption for the past 60-days. Residential users can create water budget based on household size and lawn area. The City just added resolution to gallons instead of cubic feet to make it easier for residential users to understand how much water they are using. Residents have asked for customized alerts, but the City has not added this feature because they would need to add it for all residents and not all have created a water budget. An alert system is set for irrigation users and will send them an email/text message if water use is > 110 percent of budget. The City just issued an RFP for a commercially available system which will allow residents to set alerts and for the system to integrate with on-line bill pay.

Have you seen any reduction in water use after switching to AMR/AMI?

Budget-based rates have led to a reduction in water use, mostly due to a reduction in overwatering. The City sends leak alerts to customers based on the automated report in the MDM system. Informing customers of leaks has led to a large increase in the amount of customer service needed. The City hired one additional contract worker to handle increase in calls, but the long term plan to have more self-service options through new online system. Currently, there is no requirement for the customer to fix leaks, though they typically do to decrease their water bill. The City is currently passing a resolution to require fixing due to governor's direction.

Were there any unexpected successes or issues in your transition to AMR/AMI?

There was some radio interference, which Sensus came out to resolve. Radio interference is not expected with a private radio frequency system. Due to the interference, the City was only getting 90 to 95 percent of the readings. Sensus determined that the interference was coming from a Nextel repeater at the college, and they shut it down.

City of San Bruno – Jim Burch, Deputy Director, Public Services – Maintenance and Operations, 650-616-7179

How long have you had AMR/AMI? What factors influenced your decision to go to AMR/AMI?

San Bruno had been talking about changing over to AMI from AMR for a few years. The first installation started first in July 2015. Phase 1 of the program involved replacement of 10,511 residential meter were replaced from July to March. Billing started as soon as the meters were replaced, and the system has been fully operational since May or June.

Phase 2 of the program will be the replacement of 900 commercial units that are currently on a TouchRead system. Jim is hoping to get approval from the City Council by the end of year.

Which supplier/manufacturer do you use? Why did you select that company? What other metering systems did you consider?

San Bruno already had Sensus TouchRead system, so they didn't evaluate all the options available and instead built upon the existing Sensus system. They did look at the other systems and thought that the communication network was more reliable than other systems, especially due to the geography in San Bruno. Sensus uses a dedicated radio frequency, which most of the other systems don't use. Had to install four towers.

What did you have before AMR/AMI?

San Bruno used a TouchRead system for the last 20 years. The infrastructure was old and there had been multiple mechanical failures, which lead to the upgrade to an AMI system.

How has the maintenance compared to what you expected? More time/less time?

No maintenance on base stations yet. The biggest adaptation for operators has been learning how to program and troubleshoot meters.

Have you seen a reduction in operating cost in the field and/or office?

There have been substantial increases to efficiency by the billing team. Previously San Bruno had a two-month billing cycle (a single meter reader who took about two months to read the routes). Customers would receive their bill and call the Billing Department or come to City Hall to discuss why the bill was so high, but with only one read every two months the Billing Department didn't have any other information to give to the customer. Now, with hourly data the Billing Department can pull up the customer's data and have more productive conversations to help the customer troubleshoot the issue.

Additionally, San Bruno has a leak forgiveness program, where the City will pay for half the customer's bill if the customer shows that they fixed the leak. This program cost the City about $70,000 per year. Now the City sets a threshold on water use for residential customers and puts out a door hanger or talks to the customer if they go over this threshold in any 24-hour period. If the customer is present when the door hanger is delivered, the operator will pull up the customer's hourly water use to show them the issue.

For AMI utilities – Have you integrated the AMI software with any other interfaces (SCADA/GIS/etc.)

No SCADA or GIS integration yet. These may be considered in the future, but Jim thought that it was best to start small and add on once they have learned all of the existing features. For example, the AMI software can be used to set up "virtual meters" to determine overall consumption in a specified area, which can be compared to production to identify leaks.

For AMI utilities – Do your customers use the AMI capabilities such as real-time consumption monitoring?

Customer use an online portal to track hourly/daily/monthly water usage and to compare to previous use. The customer can set their own alerts to be notified by text if their water use goes over a self-specified amount. They can also pinpoint the times in which they are using water (e.g., large spike at 3 am helped a customer identify a water sprinkler break)

Have you seen any reduction in water use after switching to AMR/AMI?

Since the AMI system is new and the City is small, they haven't had the resources to investigate this yet. However, Jim would like to use the virtual meters to help identify areas of water loss and develop a prioritized CIP for City Council.

Were there any unexpected successes or issues in your transition to AMR/AMI?

Golden State did a tremendous job with integration on software side. Part of success was with having billing folks up front and present in early discussions. Craig helped to keep communication going with all the changes, of which there were many and made a lot of the Public Works staff apprehensive at the start of the project. Jim could not overstate how helpful Craig was during this collaboration process and how instrumental he was with the success of the integration process.

The installation of the AMI system was scheduled to be completed by the end of November 2015 but was not completed until March. This was due to numerous issues in the field during meter installation that the City and the contractor had not anticipated. Meters had been in ground for 40 to 50 years so it wasn't very easy to take out some of the meters which cost the contractor time. Meter boxes were full of dirt, but it wasn't specified in the contract if the contractor was responsible for clearing out the dirt. The City went out ahead of contractor to clean out the boxes, which helped keep the installations moving. Additionally, due to the age of the infrastructure (and maybe the force used by the contractor) many of the curb stops were broken in the meter replacement process and needed to be replaced. Some of the customers' lines in older parts of the City were galvanized steel that broke easily when meter was removed. The replacement process wasn't covered in the contract and the workers weren't all plumbers that were qualified to fix the broken pipe.

San Bruno found during the installation that older homes may have electricity grounded to water line. During installation, the City received some reports from customers about TVs/light issues but they thought it was a PG&E issue. It wasn't until they looked at the water usage reported from the meters that they traced it back to the electrical ground. The electricity was interfering with some electromagnetic flow meters. (The electricity would not affect positive displacement meters.)

City of Ceres – Jeremy Damas, Public Works Director, 209-538-5717

How long have you had AMR/AMI? What factors influenced your decision to go to AMR/AMI?

The City has had AMI since 2011.

Which supplier/manufacturer do you use? Why did you select that company? What other metering systems did you consider?

Initially Public Works recommended that the City go to a Badger AMR system. A Sensus representative at the council meeting recommended a full AMI system instead. Council directed Public Works to install the Sensus AMI.

What did you have before AMR/AMI?

600 commercial accounts were on a drive by AMR system. All residential units were on a flat rate system prior to AMI.

How has the maintenance compared to what you expected? More time/less time?

Other than the SR-II meters needing to be replaced the other unexpected maintenance has been for the meter-side radio system. Sensus recommended a dual port radio system, which has led to a lot of system issues and complete failure to communicate. Most of the dual port radios have been removed. Approximately 10 to 20 issues on radio detected each month.

Have you seen a reduction in operating cost in the field and/or office?

Staff time increased 8 to 16 hours per week. Phone rings off the hook due to online system, so Jeremy hired an additional full-time staff to handle these calls. AMI has not affected (increased or decreased) the time spent by accounting in preparing the billing.

The City created a custom tool that used the FlexNet to determine leaks and high consumption. This results in approximately 20 to 30 residences that need to be notified each month.

For AMI utilities – Have you integrated the AMI software with any other interfaces (SCADA/GIS/etc.)

No, no need at this time.

For AMI utilities – Do your customers use the AMI capabilities such as real-time consumption monitoring?

There initially was a lot of customer push-back moving from a flat rate system to tiered pricing. The City did an initial study (meters installed at a representative number of homes) to find out how much water each residence would be expected to use. Even with this study, customers were afraid of the unknown, and had a lot of concerns with metering each home.

The City had a custom online portal created for customers to login and review their water use (daily, hourly, weekly, monthly, annual data charts). Additionally, notifications can be set up for leaks or high consumption to be sent by email/text message. Only 12 percent of the residences are signed up for the online system, as it is optional for all customers.

Have you seen any reduction in water use after switching to AMR/AMI?

No. Any water use reduction is due to drought-related conservation. The City has not seen the 20 percent reduction that was expected based on AWWA standards for utilities moving from flat rate to metered rates. The system does identify about 20 to 30 residences each month that have potential leaks. The City is on a groundwater supply, so it is difficult for them to determine if there is a reduction in the unaccounted for water. The overall water loss amount bounces each month, to be overall loss to overall gain.

Were there any unexpected successes or issues in your transition to AMR/AMI?

Sensus radio works well. The City typically only has a 0.04percent fail rate each read. Reports within FlexNet system do not work, so the City has had to create their own custom reports within the FlexNet software. The City has had multiple issues with Sensus meters, especially the SR-II. These issues have including leaking in the bottom flange, knocking at the meter, and other mechanical failures. The City has been replacing the SR-II with Badger meters, which integrate very well with the Sensus FlexNet system.

Finance is able to use the data fairly seamlessly. There is some data conversion needed before direct input into the Eden system for billing.

Customers needed a way to view the data, but when the City started using FlexNet this capability was not yet available despite promises from Sensus that it would be ready. The City had to create a fully-customized online portal for customers.

City of Sacramento – Jon Conover, Meter Shop Supervisor, 916-808-4891

How long have you had AMR/AMI? What factors influenced your decision to go to AMR/AMI?

The City first installed an AMR system about 13-15 years ago, using the Badger Trace drive-by AMR. The system was implemented right when Badger was developing a new drive-by platform, the Badger Orion CE. The City upgraded to this system a few years later. In 2009, the City transitioned to AMI. This was mainly due to a desire to increase customer service. With AMI, the City can use the collected data for leak detection, customer notifications, or enforcing watering restrictions.

Which supplier/manufacturer do you use? Why did you select that company? What other metering systems did you consider?

During the 2009 transition to AMI, the City chose the Datamatic mesh AMI system. The City had a lot of issues with the meters and the battery life (hundreds of replacements per month). Originally, it was thought this was an issue with meters manufactured in Malaysia, but the City had the same issues with USA products. The issues were so frequent that the City had to hire an additional staff to replace meters. Zenner bought Datamatic when Datamatic filed for bankruptcy. The City still experienced issues under Zenner and switched back to Badger two years ago.

The City evaluated both Aclara and Badger when they were switching from Datamatic. The main reason that the City chose to go with the Badger Orion AMI system is that Badger seemed to want to constantly improve the technology. Aclara had a very strong customer base but seemed less likely to advance the technology. Aclara estimated the need for less collectors than Badger (80 versus 200), so it may have been less costly on installation to choose Aclara. However, the City had heard from other agencies that they have had to install more Aclara collectors than originally estimated by the manufacturer – when reads are missed Aclara suggests that more collectors are the solution rather than an issue with the endpoint. Additionally, Badger had more features than Aclara. The Badger endpoint stores 90 days of hourly data, Aclara stores much less (something like 4 hours). While the logged data is not transmitted to the collector, the City is able to download the data from the meter if the customer calls and requests the hourly data during the time period. To calculate water use during missed read periods, Badger averages demand from the read before and the read after the missed time.

What did you have before AMR/AMI?

The City has had either AMR or AMI for the last 13 to 15 years.

How has the maintenance compared to what you expected? More time/less time?

The City has had a great experience with maintenance on the Badger meters. They have seen under 1percent failures with Badger meters and have had great customer service. When meters break, they just send it back and Badger fixes the meter. The batteries have a 20-year warranty – failures in the first 10 years are replaced free of charge and after 10-years replacement costs are prorated.

Have you seen a reduction in operating cost in the field and/or office?

The City added four staff for meter response after the switch to AMI. The AMI system costs more to operate than AMR, due to the increased maintenance on the meters that are detected using the AMI software analytics.

For AMI utilities – Have you integrated the AMI software with any other interfaces (SCADA/GIS/etc.)

The City does not currently integrate any software with the AMI system. However, they have started using a separate Trimble software to integrate with GIS and Cityworks CMMS. When staff replace an old meter, they use the Trimble to record meter box information (address, GPS location, picture, condition, etc.). The record is transmitted to the Cityworks CMMS along with any work orders for replacement.

For AMI utilities – Do your customers use the AMI capabilities such as real-time consumption monitoring?

The City chose to implement a customer interface called IonWater. They have been able to work with the City to implement new features. For example, when a read is missed Badger just uses the read before the missed read and after the missed read to provide an average water use during the outage. IonWater added in a feature to color these bars different and include an explanation, to help customers understand why the portal may show water demands in a time that they weren't using water. Sheri Adams is the program manager and primary point of contact for the City on the on-going use of this interface, and she can be reached at 916-808-1470.

This increased customer service is one of the key reasons the City chose to implement AMI. Jon would not recommend AMI to an agency that is only looking to use meter data for monthly billing.

Have you seen any reduction in water use after switching to AMR/AMI?

The City has recently started sending out notifications to customers about leaks. Customers contact maintenance staff assist if needed to determine the leak source. This has increased workload but is manageable with current staff. Some of the leaks are at the meter, which if they are caught early, have been the responsibility of the contractor to fix.

Were there any unexpected successes or issues in your transition to AMR/AMI?

Manufacturer's specifications for lid-mounted endpoints include a hole through lid. While this shouldn't be problem with concrete or fiberglass lids, it may be more difficult with heavy traffic-rated lids. Jon recommends that agencies evaluate meter box lids for signal strength getting out of meter box prior to installing new meters. This will allow agencies to build in costs for lid replacement into the project.

The City currently has about 84,000 Orion SE meters in the ground. There are still a few drive-by AMR meters, leftover from both the Datamatic and Badger AMR systems. These meters are currently being replaced. The City's experience has been that meters from manufacturers other than the AMI system manufacturer (in their case, Badger) may work in reporting water demand, but other features such as backflow alarms do not always work between manufacturers.

Jon also recommends doing a pilot to test different meters, if possible. Jon is on the AWWA Meter committee, and stated that AWWA is currently writing the standards for no-moving parts meters (electromagnetic pulse meters), but no such standard exists at this time. Jon has tested multiple manufacturer's meters, and has seen many that advance with no water running, register too high or too low, etc. This has been confirmed by other agencies in their testing, and is not limited to one manufacturer (e.g., Sensus iPERL®). Meter manufacturers will say that the high and low reads even out over time for an accurate total read. Part of the error may be human – endpoints count the number of pulses and the volume per pulse has to be programmed for each meter during installation. Jon's recommendation is to remain with positive displacement meters (e.g., Sensus SR-II), and he even had the City remove all no-moving parts meters that they had previously installed.

The City is currently conducting a Badger cellular pilot – reads are transmitted through cell signals, using whichever carrier has the best signal at the time, instead of radio transmission. The City installed 14 meters in areas of expected poor reads such as basements and parking garages, mostly in downtown. The results have been very good – Jon recommends including cellular-read in any pilot study.

City of Woodland – Jeremy Cox, Water Systems Administrator, 530-661-5882

How long have you had AMR/AMI? What factors influenced your decision to go to AMR/AMI?

The City implemented AMI in 2010. The City had to install meters in accordance with AB 2572, and chose to install an AMI system due to the added benefits of collecting real-time data. The City has 15,000 to 16,000 water meters served by two repeaters that pull a signal once every hour.

Which supplier/manufacturer do you use? Why did you select that company? What other metering systems did you consider?

The City chose Sensus because they already had Sensus water meters. Sensus is a commonly-installed meter in the Sacramento and Bay Area, and they provide good technical support with fast response from Folsom. Jeremy has found that it's best to keep all AMI system components within the same manufacturer. The City had some meters that were not Sensus, and they didn't work.

The City likes that Sensus uses a dedicated, private FCC bandwidth to transmit data instead of a public radio frequency. Overall, there have been very few issues transmitting the reads. Some meters had a high SNR (signal to noise ratio) which caused issues with the meters reading, but Sensus was able to solve the programming issues and fixed the problem.

What did you have before AMR/AMI?

The City had flat-rate billing for residential with no meters. Some of the high-flow commercial users had meters that were read manually.

Once the AMI system was installed, customers received sample bills for the first 6-month transition period before actual billing from the AMI data occurred.

How has the maintenance compared to what you expected? More time/less time?

Since the City did not have meters for residential customers before, they had to add two meter technicians to handle increase in maintenance and to collect missed reads. Jeremy believes that some of these issues would have been avoided if new meters were installed at the same time as the AMI system, instead of retrofitting the old meters to work with the AMI system.

Have you seen a reduction in operating cost in the field and/or office?

While the City has not added additional staff in finance, there has been an increase in workload. The billing takes longer than before, and there is additional work in updating their records anytime a new meter or register is installed.

For AMI utilities – Have you integrated the AMI software with any other interfaces (SCADA/GIS/etc.)

The City has a GIS-interface with the AMI software, which allows staff to click on meters in GIS to pull up the meter data.

For AMI utilities – Do your customers use the AMI capabilities such as real-time consumption monitoring?

The City chose the AquaHawk customer portal to allow customers to see water meter usage and sets alerts. AquaHawk was implemented over the past 6 months to 1 year. Sensus MDM software had customer facing platform, but the City did not think it was very user-friendly. The City has a dedicated staff for monitoring the system though AquaHawk for issues/leaks – Jordan Power, 530-661-2067.

Have you seen any reduction in water use after switching to AMR/AMI?

The City saw a 25 percent reduction in water use when they went from flat-rate to metered billing. The leak-detection capabilities of AMI were not a major factor in transitioning to AMI.

Were there any unexpected successes or issues in your transition to AMR/AMI?

One of the biggest hurdles was getting the billing system to work with the metered data. There were sites with meters that didn't exist in the billing software. During construction, the City found more than 100 connections that occurred on the same property as another meter. The costs for rerouting the water line to a single metered location were greater than installing two meters. The City had received federal funding for the meter replacement program, and they couldn't justify increased cost for repiping. However, this means that there are two meter reads to combine in the billing software and two meters to maintain.

Jeremy recommends testing a portion of the meters throughout the City for accuracy prior to installing the transmitters. Some of the older meters may need to be replaced before switching to AMR/AMI, which should be added into the scope of the AMR/AMI CIP. The meters are relatively low cost ($150) and new meters would help avoid immediate maintenance issues that occur with older meters. Some of the old registers may not be able to provide accuracy to 1 cubic foot – with AMI, 1 cubic foot accuracy is needed to provide optimal leak detection ability. Additionally, older (pre-2010) positive-displacement meters such as the SR-II meters have lead above what is permitted in meters sold today. The City interprets AB 1953 as prohibiting them from repair broken SR-II meters, so they have been replacing them with the Sensus iPERL®. Jeremy recommends no-moving parts meters (e.g., Sensus iPERL®) due to the low maintenance.

APPENDIX E

Minimum Site Requirements for Storage Tanks

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Minimum Site Requirements for Storage Tanks

This appendix documents the minimum estimated site requirements for storage tanks. As discussed in Chapters 7 and 8, storage is recommended to mitigate emergency, operational, and fire flow storage deficiencies in the Lower and High Pressure Zones. Chapter 8 provided the recommended tank volume and Chapter 9 provided an estimated capital cost. However, a tank siting analysis was not completed as part of this Master Plan and is recommended when MPMW moves forward with implementing the storage tank. Land acquisition within Menlo Park city limits can be cost prohibitive and will likely be one of the more difficult components in the implementation of storage in these zones. However, Table 1 below was prepared in an effort to provide MPMW with guidance for identifying whether a potential parcel could be a feasible location to accommodate storage.[1]

Table 1 summarizes the estimated minimum site requirements for a water storage tank. Estimates for cylindrical tanks were prepared at various nominal storage volumes and heights. These estimates were prepared by assuming the following:

- An overall dead-storage height of ten feet, which assumes:
  - Two feet of dead storage (height between the bottom of tank and suction of the booster pump station);
  - Two feet of freeboard from the high-water-level and the overflow level; and,
  - Six feet of sloshing height allowance required to accommodate sloshing waves during an earthquake.

Table 1. Estimated Minimum Site Requirements of Water Storage Tank

Nominal Storage Volume, MG	Estimated Tank Slab Diameter and Area Associated with Varying Tank Heights(a,b)			
	Height = 20 feet		Height = 40 feet	
	Acres	Diameter	Acres	Diameter
2.0	0.70	185	0.30	110
2.5	0.85	210	0.35	120
3.0	1.00	230	0.40	135

(a) Assumes that there is 2 feet of dead storage, 2 feet of freeboard from the overflow level, and additional 6 feet of freeboard for a sloshing height allowance.

(b) Slab diameter/footprint includes the additional footprint associated with the required booster pump station; which is estimated to add an additional 3,000 square feet.

[1] It is worth noting that vacant land is not necessarily required for the purposes of implementing a storage tank. Existing City-Owned parks could be leased by MPMW and could be redeveloped to include a partially buried to fully buried tank.

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APPENDIX F

Cost Estimating Assumptions

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Appendix F
Cost Estimating Assumptions

Overview

This appendix provides the assumptions used by West Yost to develop an opinion of the probable construction cost for the planning and design of recommended water system facilities for the City's water system. The opinion of probable construction cost was developed based on a combination of data supplied by manufacturers, published industry standard cost data and curves, construction costs for similar facilities built by other public agencies, and construction costs previously estimated by West Yost for similar facilities with similar construction cost indexes.

Additionally, the costs presented in this appendix are for construction only and do not include uncertainties in estimation or unexpected construction costs (e.g., variations in final quantities) or cost estimates for land acquisition, engineering, legal costs, environmental review, soils investigation, surveying, construction management, and inspections and/or contract administration. Some of these additional cost items are referred to as contingency costs or mark-ups, and are further described in the last section of this appendix.

The opinion of probable construction cost has been adjusted to reflect August 2017 costs at an Engineering News Record (ENR) Construction Cost Index (CCI) of 12,037 (San Francisco Average). These construction costs are to be used for conceptual cost estimates only, and should be updated regularly. Construction costs presented in this appendix are not intended to represent the lowest prices in the industry for each type of construction; rather they are representative of average or typical construction costs. These planning-level construction costs have been prepared for guidance in evaluating various facility improvement options, and are intended for budgetary purposes only, within the context of this master planning effort.

The following sections of this appendix describe the assumptions used to develop the opinion of probable construction cost for the planning and design of recommended water system facilities for the City's potable water system.

Water System Construction Costs

The following sections present the assumptions used to develop the opinion of probable construction cost for recommended facilities in the City's water system and are categorized by improvement project type.

Storage Reservoirs

Table 1 summarizes the construction costs for water storage reservoirs for the size range of 1.0 to 3.0 MG. These costs generally include the installation of the storage tank, site piping, earthwork, paving, instrumentation, and all related sitework. Costs do not include land acquisition. It should be noted that these costs are representative of construction conducted under normal excavation and foundation conditions for a partially or fully buried tank (up to about 20 feet in depth below grade). Costs also assume relatively minor earthwork and grading to level the tank site and does not include significant grading or excavation to clear a site for a tank. It should be noted that if special conditions exist such as high groundwater levels, salinity levels, fill above storage reservoir, costs may increase dramatically. Cost assumptions are for partially or fully buried reinforced concrete tanks.

Table 1. Construction Costs for Partially or Fully Buried Reinforced Concrete Water Storage Reservoirs[a]	
Capacity, MG	Estimated Construction Cost, million dollars
1.0	2.5
2.0	4.5
3.0	6.8

(a) Based on August 2017 ENR CCI of 12,037 (San Francisco Average).

Pump Stations

Pump stations will be required to lift water from storage reservoirs and/or adjacent pressure zones. Average construction costs for distribution pumping stations, shown in Table 2, are based on enclosed stations with architectural and landscaping treatment suitable for residential areas. It should be noted that pump station costs can vary considerably, depending on factors such as architectural design, pumping head, and pumping capacity. Therefore, these costs presented below are representative of construction conducted under common or normal conditions, and would be significantly higher for special or difficult conditions.

Pump station costs include the installation of the pumps, site piping, earthwork, paving, on-site backup/standby power generator, SCADA, and all related sitework.

Table 2. Construction Costs for Pump Stations[a]	
Firm Capacity[b], mgd	Estimated Construction Cost, million dollars
0.5	1.3
1	1.4
2	1.6
3	1.7
5	2.1
8	2.6
10	2.9
12	3.0

(a) Based on August 2017 ENR CCI of 12,037 (San Francisco Average).
(b) Equal to the total pumping capacity with the largest pump assumed out of service or on standby (i.e., firm capacity).

Pipelines

Table 3 presents unit construction costs for potable water pipelines 8 through 18-inches in diameter. These unit costs are for pipeline construction in developed areas and are representative of pipeline construction conducted under common or normal conditions. These unit costs would be significantly higher under special or difficult conditions.

The unit construction costs presented below generally include pipeline materials, trenching, placing and jointing pipe, valves, fittings, hydrants, service connections, placing imported pipe bedding, native backfill material, and asphalt pavement replacement, if required. However, the costs presented in Table 3 do not include the cost of boring and jacking pipe. Pipeline bore and jack costs are shown in Table 4 and should be added where required for this purpose.

Table 3. Unit Construction Costs for Pipelines[(a,b)]

Pipeline Diameter, inches	Unit Construction Cost, $/linear foot
8	260
10	320
12	370
14	420
16	460
18	500

(a) Costs based on San Francisco Peninsula pipeline cost estimates, scaled up to August 2017 ENR CCI of 12,037 (San Francisco Average).
(b) Costs based on ductile iron cement-lined pipe.

Table 4. Unit Construction Costs for Jack and Bore[(a,b)]

Pipeline Size	Unit Construction Cost, $/linear foot
8-inch diameter (16-inch diameter casing)	690
12-inch diameter (24-inch diameter casing)	1,010
16-inch diameter (30-inch diameter casing)	1,270

(a) Costs based on San Francisco Peninsula pipeline cost estimates, scaled up to August 2017 ENR CCI of 12,037 (San Francisco Average).
(b) Conductor pipe is not included in cost.

Valve Regulating Stations and Check Valves

Pressure regulating stations are required to provide water supply to pressure zones with pressure demands less than the average SFPUC turnout pressure.

- The construction cost for a new pressure regulating station or an existing pressure regulating station upgrade under normal conditions is estimated to be approximately $290,000.
- The construction cost for a new pressure regulating station or an existing pressure regulating station upgrade under special or difficult conditions (e.g., construction in high traffic areas) is estimated to be approximately $340,000.
- The construction cost for a check valve connection is estimated to be approximately $12,000.

Construction costs for a pressure regulating station include the installation of control valve(s), a concrete utility vault, access hatches, site piping, earthwork, paving, SCADA, and related sitework.

Contingency Costs and Mark-ups

Contingency costs or mark-ups must be reviewed on a case-by-case basis because they will vary considerably with each construction project. However, to assist City staff with budgeting for recommended water system facility improvements, the following percentages were developed.

- Design and Construction Contingencies (30 percent): The construction costs presented above are representative of the construction of potable water system facilities under normal construction conditions and schedules; consequently, it is appropriate to allow for estimating and construction uncertainties unavoidably associated with the conceptual planning of projects. Factors such as unexpected construction conditions, the need for unforeseen mechanical items, and variations in design and final quantities are only a few of the items that can increase project costs.
- Professional Services (30 percent): Professional services have been divided into four categories as shown below.

Design:	10 percent
Construction Management and Inspection:	10 percent
Permitting, Regulatory and CEQA Compliance:	5 percent
City Administration, Public Outreach, and Legal:	5 percent
Total:	**30 percent**

Design services associated with new facilities include preliminary investigations and reports, right-of-way acquisition, foundation explorations, preparation of drawings and specifications for construction, surveying and staking, sampling of testing material, and start-up services. Construction management covers items such as contract management and inspection during construction. City administration, public outreach and legal covers items such as legal fees, financing expenses, and interest during construction.

The total markup, including contingencies and professional services, is compounded, and amounts to 69 percent of the estimated construction cost. However, it must be noted that for smaller or more complicated projects, the design cost may increase by 10 to 20 percent of the estimated construction cost.

An example application of these standard mark-ups to a project with an assumed base construction cost of $1.0 million is shown in Table 5. As shown, the total cost of all project markups is 69 percent of the base construction cost for each construction project.

Table 5. Example Application of Project Cost Mark-ups

Cost Component	Percent	Cost
Estimated Base Construction Cost[a]		$1,000,000
Contingencies:		
Design and Construction Contingencies	30%	$300,000
Estimated Project Cost after Design and Construction Contingencies		$1,300,000
Professional Services		
Design	10%	$130,000
Construction Management and Inspection	10%	$130,000
Permitting, Regulatory and CEQA Compliance	5%	$65,000
City Administration, Public Outreach, and Legal	5%	$65,000
Estimated Professional Services Total		$390,000
Estimated Total Project Cost		**$1,690,000**

(a) Assumed cost of an example project.

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APPENDIX G

Review of MPMW Staffing Assessment Findings
March 2017

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CITY OF MENLO PARK

STAFF REPORT

City Council
Meeting Date: 3/28/2017
Staff Report Number: 17-067-CC

Study Session: **Water System Master Plan (WSMP) – Review of Menlo Park Municipal Water (MPMW) Staffing Assessment findings**

Recommendation

Staff requests that the City Council provide feedback on the WSMP Staffing Assessment findings and proposed strategy to adequately maintain the water system and continue providing reliable service and delivery of drinking water to MPMW customers.

Policy Issues

In May 2015, the City Council identified the development of the WSMP as a priority project. The WSMP, which is included in the 2017 Council Work Plan, is on track for completion by the end of this year. The development of the WSMP is consistent with the MPMW's goals and primary mission, "the preservation of the public welfare, health, peace and safety of the City of Menlo Park and its inhabitants" (ordinance 222, 1952).

Background

In 1952, the City formed the MPMW as a self-supporting City enterprise. The role of the MPMW was defined as the entity responsible for the sale of water and for controlling the construction and operation and maintenance of the water system. During that time (period from 1949 to 1952), the City annexed the areas known as Belle Haven, Nash Tract and the U.S. Veterans Hospital which were served by the Willow Road County Water District. With the annexation of these areas, the City took over the operation of the Willow Road County Water District and created the MPMW. Since then, the MPMW has undergone a number of system expansions. In 1956, water mains were installed to serve the Bohannon Industrial Tract. Following that expansion, the MPMW acquired the water system serving the areas along Commonwealth Drive from the California Services Company. Later, the MPMW expanded its service area to the Sharon Heights and Stanford Hills subdivisions when those lands were annexed and developed. In 1962, the first Sand Hill Reservoir (No. 1) was built and the Sharon Heights Pump Station was upgraded. Following the expansion in the Sharon Heights area, the MPMW purchased part of the North Palo Alto water system in 1967, which was owned and operated by the City of Palo Alto. The North Palo Alto system served the Willows neighborhood.

The next expansion focused on the Haven Avenue area as the MPMW began providing water services to a section of Redwood City. In 1997, the second Sand Hill Reservoir was built (No. 2). In 2001, the MPMW's service area expanded to include properties located within the City limits that were being served by the East Palo Alto County Waterworks District (O'Brien Drive and Euclid Street). The incorporation of these City properties into the service area was consistent with the City's political jurisdiction that currently maintains taxing, building, planning, and zoning authority, and provides police and storm drainage services. Presently, the MPMW service area includes the Upper Zone, which covers the Sharon Heights area, and the Lower and High Pressure Zones, which include areas extending from east of El Camino Real to the San Francisco Bay (Attachment A).

For the past 65 years, the MPMW has been providing water purchased from the San Francisco Public Utilities (SFPUC) to properties located in its service area. The MPMW has had a history of reliable service and low rates, compared to neighboring agencies. Similar to the ownership and operation of most of its neighboring agencies (i.e., the cities of Redwood City, Palo Alto, Mountain View), the MPMW is a publicly owned and operated enterprise (Attachment B). Other neighbors include the California Water Service (Cal Water), an investor-owned private utility that serves half of the City and the O'Connor Tract Water Co-operative Water Company, a non-profit organization founded in 1921 that serves a section of the Willows neighborhood in the City and a number of apartment buildings in the City of East Palo Alto.

The MPMW is a also a member agency of the Bay Area Water Supply and Conservation Agency (BAWSCA), which represents water purveyors that purchase water from the SFPUC. Of the 26 BAWSCA member agencies, 16 are cities, 8 are districts and 2 are private utilities (Cal Water and Stanford University). The BAWSCA public member agencies are publicly managed, with the exception of the City of East Palo Alto's water system, which is operated by American Water, a private company.

As a public entity, the MPMW has ownership of the system and thereby control of development and economic growth, construction, operation and maintenance responsibilities and is under the supervision of the City Manager (Municipal Code Sections 2.48.010 and 2.48.020). All revenues from the sale of water are administered through the "Menlo Park municipal water fund" and can only be used for water services provided to MPMW customers (Municipal Code Sections 3.24.010 and 3.24.020).

Presently, approximately 16,000 customers are served through approximately 4,000 service connections. Since the water distribution system serves between 10,001 and 50,000 customers, it holds a D3 Distribution System Classification per the State's classification system. The water distribution system consists of 55 miles of water mains, 3 distribution zones, 2 reservoirs, 1 pump station, 366 fire hydrants and 1,392 valves. On average, customers use 2.8 million gallons a day.

In the last 5 years, the MPMW has undertaken a number of capital improvement projects to improve the water distribution system, as follows:

- The Sharon Heights Pump Station project was completed in 2015, greatly improving the reliability of the system in the Upper Zone;
- As part of the water main replacement program, approximately 2,500 feet of earthquake resistant pipe were installed on Trinity Drive in 2015, replacing aging asbestos cement piping serving the homes in that area;
- In 2015, staff began the development of the WSMP, which will enable the MPMW to strategize future planning and budgeting efforts in order to maintain distribution reliability and efficiency under current demands, future growth, and emergency situations;
- The first of a three emergency water supply wells has been drilled and is expected to be completed by the end of 2017; and
- In July 2016, staff began the process of identifying locations for two additional emergency supply wells, which will be followed by an environmental review and design. The options for emergency supply and storage are tentatively scheduled to be presented to Council this April.

While a number of improvement projects have been implemented, the WSMP will lay out a 25 year capital improvement program and identify long-term maintenance and operational recommendations. In addition, the scope of work includes a comprehensive analysis of the MPMW's current operations, services, and organizational structure to assess the staffing level needs required to provide safe and efficient services. This assessment, completed at the end of 2016, indicates that current staffing levels are not adequate enough to allow for the implementation of a preventive maintenance program.

Based on the staffing assessment findings, the Consultant is recommending the addition of 4 full-time certified operators to adequately maintain and operate the water system. This recommendation would increase the total number of MPMW staff from 3 to 7. A summary of the Consultant's recommended maintenance programs and level of effort is included in Attachment C.

Analysis

As discussed earlier, the goal of the MPMW is to provide customers with safe, high-quality drinking water at all times, to fully comply with all drinking water regulations and standards and to provide fire protection services. In order to ensure the reliability of the water distribution system, an adequate number of staff is required.

Current Staffing

The system is maintained and operated by a Water System Supervisor (currently vacant), a Water Quality Specialist and a Water System Operator II. State law requires that operators responsible for maintaining and operating a water system hold certifications from the State Water Resources Control Board (Water Board). Current permanent staff holds the required certifications from the Water Board for the operation of a D3 water system. Support services for tasks that do not require a certified operator are provided through up to 2 temporary workers.

In 2016, the water system supervisor resigned. Since then, the MPMW has been in the process of trying to fill the position. A posting in December 2016 was unsuccessful due to a low number of responses from qualified applicants. A second posting closed in February and a conditional offer of employment has been made.

Support Services

A number of MPMW functions are currently provided through private contractors and consultants. These services include water meter reading and emergency and scheduled repairs. A summary of these support services is provided below.

Water Meter Reading, Billing and Customer Services – In 1994, staff began the process of analyzing the cost and benefits of contracting the water meter reading, billing, and customer service functions to private companies. Beginning in September 1995, these services were outsourced to Cal Water who provided them until April 2010. In 2010, a request of proposals (RFP) was issued to for water meter reading, billing and customer service. Through that process, the City Council awarded a contract to Global Water. In 2016, another RFP was issued and Global Water, now Fathom, was selected for a 5 year contract. Fathom, which is based in Arizona, is responsible for the reading of all the water meters on a monthly basis, sending the bills to all of the MPMW customers, issuing work orders for meter service issues and disconnections due to non-payment and for customer service. Fathom provides customer service support over the phone. The contract with Fathom is for $336,000 annually. While Fathom covers customer services, MPMW customers often prefer to stop by City Hall to pay their bill by check or cash or for other questions regarding their bill or service. City staff answers questions for customers who prefer the personal interaction.

Cross-Connection Control Program – To ensure that the water system is protected from the potential for contamination, the State requires that the MPMW have a program to eliminate, prevent and monitor connections to customers and for the installation and testing of devices that provide backflow protection. Backflow devices are used to prevent any water from flowing back into the MPMW's water system. These devices have to be monitored and tested annually. In 2016, staff contracted the management and implementation of the cross-connection control program to the County of San Mateo Environmental Health Program. The County now ensures that all backflows installed on private service lines served by the MPMW are tested annually by certified contractors. The cost of the program is $20,875 a year. City staff continues to inspect backflows on City property.

Water Quality / Laboratory Analysis – As a service provider, the MPMW is required to ensure that the potable water provided to its customers meets water quality criteria set through State and Federal regulations. To comply with the regulations, the MPMW implements a program that consists of weekly sampling of water at a number of locations within the distribution system. In addition, quarterly, annual and other samples are taken for testing based on a number of specific constituents, based on the frequency required by the regulations. All sampling throughout the distribution system is conducted by certified MPMW staff. These water samples are sent to private laboratories for the water quality analyses. The annual cost for water quality testing is $15,000.

Emergency and Scheduled Repairs – Approximately 53% of the water distribution system consists of asbestos cement pipes that were installed over 60 years ago. Due to their material and age, these pipes are now experiencing failures, which can happen at any time of the day and night. Water main failures result in the interruption of water delivery to customers and roadway damage. As a result, they have to be addressed promptly so services can be restored and customers can begin to receive water with minimal interruption. However, due to the limited staff and lack of equipment, the MPMW cannot make repairs to the water system resulting from most water main breaks. Emergency and scheduled repair assistance is therefore provided through an on-call agreement with three contractors. These contractors work on repairs that can be scheduled during the weekday and normal operating hours. These contractors are also able to provide 24-hour services to assist MPMW staff during emergencies. The repair contract budget is $200,000 annually.

Supervisory Control and Data Acquisition (SCADA) – The MPMW uses SCADA, which is a software application, for the control and monitoring of the water system. Troubleshooting services and maintenance are provided through a private contractor. The contract budget is $20,000 annually.

Capital Improvement Projects (CIP) Design and Construction – Design projects to improve and replace the water system are managed by City staff within Public Works. In-house staff works with private consultants to develop the design for most of the CIP projects. The construction of the projects is performed by private contractors. Depending on the workload, construction inspection services are often provided by private contractors.

Staffing and Maintenance Deficiencies

Water certified staff is responsible for operating and maintaining the water system and ensuring that customers receive safe potable water at all times. Routine tasks involve the following:

- Operation and monitoring of the water system;
- Water quality testing;
- Inspection and maintenance of equipment;
- Regulatory compliance and reporting;
- Hydrant flow testing;

- Emergency response and repairs;
- Utility marking as requested due to construction activity;
- Management of contracts with private contractors;
- Inspection services for construction associated with water capital improvement projects, development and new/upgraded connections; and
- Customer service.

In order to provide safe and efficient services and ensure the reliability of the water system, operators are not only responsible for operating the system, but they should also aim to properly maintain the existing infrastructure based on industry standards and best management practices. First established in 1881, AWWA "is the largest nonprofit, scientific and educational association dedicated to managing and treating water, the world's most important resource." The industry standard, operators therefore depend on AWWA manuals to implement best management practices for the operation and maintenance of water systems.

As part of the staffing level assessment, the WSMP Consultant assessed the current operation and maintenance practices of the MPMW (Attachment C). The Consultant determined that the existing staffing levels do not allow for the proper operation of the system and implementation of preventive maintenance programs, as recommended by AWWA. Preventive maintenance involves the regular inspection and exercise of equipment to lessen the likelihood of failure. Without the implementation of an effective maintenance program, the water system is likely to exhibit premature failures that are more costly to repair when they become emergencies.

Overall, the WSMP Consultant found a number of maintenance program deficiencies which are summarized below:

Condition Assessment of Water Assets and Record Keeping – The water distribution system consists of 55 miles of water mains, 3 distribution zones, 2 reservoirs, 1 pump station, 366 fire hydrants and 1,392 valves. Currently, there is no formal assessment process conducted by MPMW staff to determine the condition of the assets nor are there maintenance records prior to 2014 that indicate the nature of system failures. As part of the WSMP, an inventory of the water assets has been completed. It is recommended that a Computerized Management Maintenance System (CMMS) be implemented to track work orders, routine maintenance and repairs of each asset. The CMMS would provide the MPMW with the information required to monitor and assess the condition of the water system moving forward.

Standard Operating Procedures (SOPs) – The MPMW does not have established SOPs that describe the maintenance procedures that need to be followed to implement a preventive maintenance program. It is recommended that procedures for specific maintenance tasks be developed.

Fire Hydrants – There are approximately 366 hydrants installed throughout the distribution system, many of which are old and of the dry barrel type, units which are suited for cold weather climates and not the Bay area. When fire hydrants break, the dry barrel units are therefore replaced with wet barrel hydrants. The American Water Works Association (AWWA) Manual M17 and the Insurance Services Office (ISO) provide guidelines and requirements for the testing and maintenance of fire hydrants. According to guidelines set by the AWWA Manual M17, hydrants should be inspected and exercised annually. ISO assesses whether a community's fire prevention and suppression capabilities are adequate based on specific criteria, which includes whether agencies are implementing a regular maintenance program for hydrants. Due to limited staff, the MPMW has not been able to implement a proactive fire hydrant maintenance program. As the water purveyor, the MPMW has the responsibility for ensuring that the water assets are properly maintained to provide customers with safe drinking water and for fire protection. The lack of a regular maintenance program for hydrants affects the MPMW's ability to provide the Menlo Park Fire District and ISO with maintenance records, which are used in risk assessments and ratings.

Pressure Reducing Valves (PRVs) – The MPMW receives water from the SFPUC through 5 turnouts, 3 of which are equipped with PRVs. The pressure of the water delivered by the SFPUC ranges between 100 to 140 pounds per square inch (psi) and is reduced through the PRV stations to 40 to 65 psi to protect water services since customers do not have the protective measures to receive water at such high pressures. The PRVs are critical to the delivery of the water as their failure would lead to elevated pressures, which would have adverse impacts on the service to customers. Due to their specialized nature, these systems require servicing by the manufacturer or qualified technicians. There is currently no program to have qualified technicians to test and rebuild the PRVs.

Valves – The water distribution system includes 1,392 valves (not including those for fire hydrants). Based on the typical valve sizes in the MPMW system, AWWA guidelines recommend that the valves be exercised every 4 to 5 years. There is currently no program in place to exercise the system valves based on AWWA guidelines. The valves that are exercised are those that need to be operated when there are water main breaks.

Reservoirs – The water system includes 2 reservoirs that service the Upper Zone. Maintenance includes cleaning for the removal of fine sediment that accumulates on the bottom of the reservoirs and inspection of the liner that protects the concrete walls and floor. It is recommended that the reservoirs be cleaned annually by a private contractor to improve the water quality conditions. There is currently no program established for annual cleaning.

Flushing – There are 61 locations in the distribution system that have dead-ends where the water can remain stagnant without receiving much movement. As a result, the water quality in these sections of pipe may suffer. To address potential water quality issues, these dead ends require annual flushing. Due to the drought, flushing activities have been placed on hold to reduce the amount of water waste. However, to protect water quality, the flushing program needs to be re-evaluated and prioritized.

In addition to the maintenance deficiencies noted, approximately 53% of the MPMW's water mains consist of aging asbestos cement lines that are over 60 years old. Much of the water system has therefore reached the end of its useful life. Due to the age and condition of the system, staff has to routinely respond to emergencies associated with piping failures and leaks during days, nights and weekends. Since the water system operates continuously, one of the permanent operators must be on-call at all times. The 3 operators rotate the on-call responsibility to provide 24/7 response to any emergencies that may happen at any time. This means that the on-call operator must be nearby and fit and ready to drive into work at any time of the day and night (weekdays and weekends). In 2015, for example, there were 24 main breaks throughout the distribution system.

The reactive nature of the operation, in combination with the existing staff levels, do not allow staff to implement a preventive maintenance program and best management practices, as recommended by AWWA, to prolong the useful life of the system and to avoid costly emergency repairs that can happen at any time of the day or night. To properly maintain the system based on AWWA recommended practices, the Consultant's recommendation is for 4 additional full-time certified operators, for a total MPMW staff of 7. As noted earlier, the City is in the process developing the first of 2 or 3 emergency water supply wells. Drilling began in February and the project is expected to be completed by the end of 2017. The new well will require routine maintenance, operation and treatment. With an additional staff of 4, staff believes that the MPMW would be able to implement a preventive maintenance program and meet the testing and operational requirements of the new well.

Staffing Level Comparison to Others

As part of the assessment, the WSMP Consultant and City staff gathered organizational and staffing level information from municipal water agencies of similar size to the MPMW and neighboring agencies. A detailed breakdown that includes the population served by each of the agencies, the number of water connections and staff levels is included as part of Attachment D. Based on the information, the comparison to other BAWSCA agencies, for example, revealed that the MPMW has fewer employees than those of similar size (Table 1). Also, by assessing the number of connections per staff as a metric for comparison to larger agencies, the findings show that each MPMW staff is responsible for 1,401 water connections – the highest of all the agencies surveyed. A San Bruno and Burlingame water operator, for example, maintains and operates between 680 and 609 connections, respectively, numbers that are less than half than those for MPMW staff. Overall, the findings indicate that the MPMW is operating at staffing levels that are much lower than the agencies surveyed. By increasing the number of water operators by 4, the number of connections per staff would drop from 1,401 to 600, aligning the MPMW with staffing levels of other agencies.

Table 1 – Staffing Level Comparison to other BAWSCA Municipalities

Utility	Location	No. of Water Connections per Staff
MPMW (3 Staff Existing)	Menlo Park, CA	1,401
MPMW (3 Staff Existing + 4 New)	Menlo Park, CA	600
Neighboring BAWSCA Agencies – Similar Size (Based on No. of Water Connections)		
East Palo Alto*	East Palo Alto, CA	750
Hillsborough	Hillsborough, CA	431
Neighboring BAWSCA Agencies – Not of Similar Size (Based on No. of Water Connections)		
Redwood City	Redwood City, CA	1,045
Mountain View	Mountain View, CA	850
Palo Alto	Palo Alto, CA	945
San Bruno	San Bruno, CA	680
Burlingame	Burlingame, CA	609
Millbrae	Millbrae, CA	936
Mid-Peninsula Water District	Belmont, CA	613

*Note: East Palo Alto's water system is managed by American Water, a private operator.

Options

The City has a number of options to address the staffing inadequacies of the MPMW. These include staffing augmentation, outsourcing the management of the water system, which includes turning over the responsibilities of certified water operators to a management agency, and the selling of all the water assets.

Public Utility, Staff Augmentation

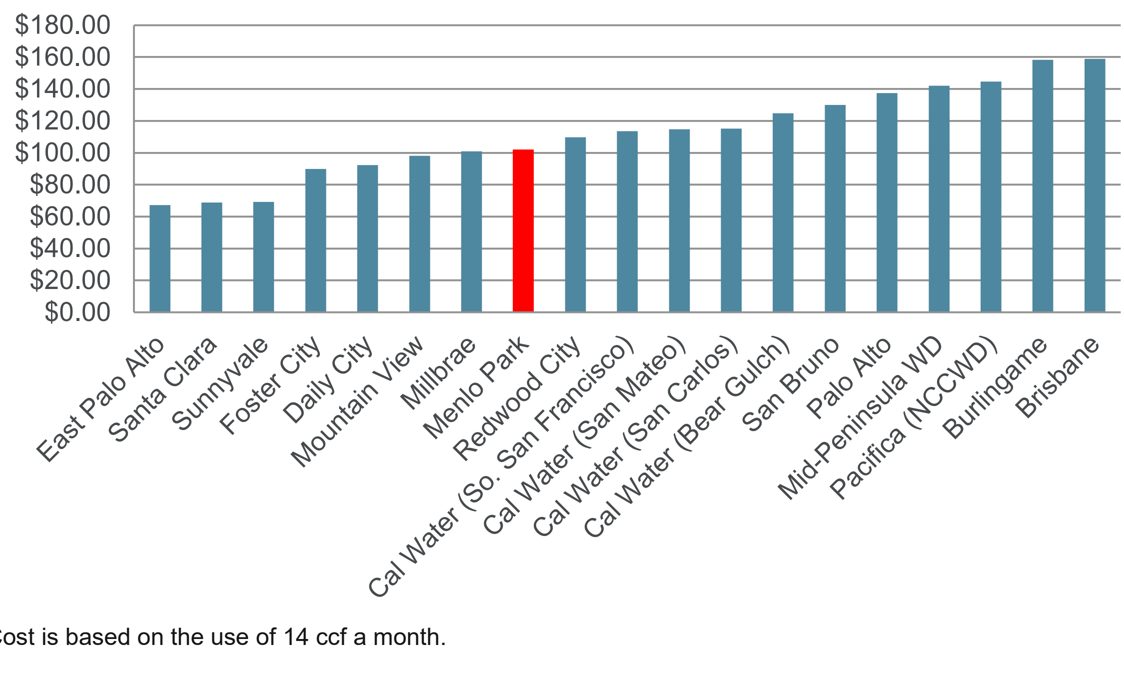
Currently, the organizational structure includes a Water System Supervisor, Water Quality Specialist and a Water System Operator II. Based on a review of the staffing needs and existing organization, the recommendation is to add a new Senior Water Operator, a second Water Quality Specialist and 2 more Water System Operators I/II. The Senior Water System Operator would have the responsibility for assisting in the guiding of staff, managing complex projects related to the repair of the water system and for implementing a preventive maintenance program. The additional Water System Operators I/II would provide assistance with the preventive maintenance tasks, while the second Water Quality Specialist would assist in ensuring that the water quality parameters are met. The proposed phasing of positions per fiscal year would be as follows:

- FY 2017/18
    - New Senior Water System Operator
    - New Water System Operator I/II
- FY 2018/19
    - New Water Quality Specialist
    - New Water System Operator I/II

By focusing on staff augmentation, the MPMW would be able to implement preventive maintenance programs and ensure the reliability of the system while retaining the management of the water distribution system. There are a number of advantages for retaining full public control of the water system. Foremost, the City would retain the rights to the allocation of water from the SFPUC and thereby have control of development within the City. Secondly, the MPMW would be managed and operated for the sole purpose of providing customers with safe, high-quality drinking water and for maintaining the water system to ensure long-term reliability. As a public utility, the MPMW water users would retain the voting rights to control rates.

Since municipalities are not for profit, revenues would only be used for operating, maintaining and improving the water system. It is important to note that the MPMW has been serving its customers with safe drinking water and fire suppression services for 65 years at reasonable costs. Compared to a number of other agencies, the adopted 2015 water rates for the MPMW are lower. Figure 1 compares the MPMW monthly water charges (for a typical resident using 14 ccf a month) to other local water agencies that also purchase SFPUC water. Ten of the agencies (including Sunnyvale, California Water Service, Mountain View, and Palo Alto) adopted new rates in 2015. The MPMW single-family residential monthly charge falls in the lower middle range compared to the other agencies. Cal Water (Bear Gulch), which serves the central part of the City, as well as the Towns of Atherton, Woodside and Portola Valley has higher rates than those of the MPMW.

Figure 1 – Monthly Single Family Residential Water Rates, FY 2016 SFPUC Agencies



Note: Cost is based on the use of 14 ccf a month.

Outsourcing

The management of water systems can be complex for municipalities given their capital intensive nature and increasingly more stringent regulatory standards. Since water systems are fully funded through customer fees, the access to financial sources to adequately operate and maintain the system can be limited. There are political challenges associated with increasing user fees to fully fund day to day operations and meet long-term capital needs. As a result, many municipalities find themselves financially stressed and unable to maintain and operate their water systems in a manner that ensures long-term reliability.

The outsourcing of functions to other entities is therefore often seen as a means of saving on operating costs. A range of partnership models, both public-public and public-private, exist that involve the outsourcing of specific functions. Currently, the MPMW contracts out a number of services, as discussed earlier, such as water meter reading, billing and emergency and scheduled repairs. The day-to-day management of the system and long-term capital improvement planning, however, is done by MPMW staff.

There are a few options available to the MPMW to outsource more functions, which would avoid the need to hire additional staff. These include the following:

- Sharing of servicers with other municipalities, such as the City of Redwood City;
- The outsourcing of the operation and maintenance of the water system to a private contractor through a long-term agreement;
- The leasing of the system to a private company; and
- The sale of the water assets.

Shared Services

Both the cities of Redwood City and Palo Alto operate and maintain their own water systems. Under a public-public partnership model, the MPMW would enter into a long-term agreement for the sharing of staff with another public entity. The arrangement would vary, depending on the level of assistance available. For example, through shared services another agency could provide certain specific services and maintenance tasks and the sharing of equipment or they could involve the complete transfer of the operating and maintenance responsibilities of the water system.

The sharing of services with other neighboring municipalities offers a number of benefits. For example, the Cities of Palo Alto and Redwood City are in close proximity and are already familiar with the operation of the SFPUC system as well as with the water quality requirements (Attachment B). The City of Palo Alto has noted that they currently do not have the staffing levels to provide assistance to another agency. Redwood City, however, already has an emergency interconnection with the MPMW and they have expressed interest in exploring options to provide services. Based on their staffing levels and equipment, they may be able to provide assistance with specific maintenance tasks. These tasks could include a valve exercising program, pump maintenance, water main repairs or water quality sampling. The City already has experience contracting with Redwood City having done so for many years for the maintenance of the Atherton Channel. The arrangement with the MPMW would be similar in nature. The MPMW would be required to manage the contract and to negotiate the terms and fees. This would require that staff inspect the services being provided, track time and effort, ensure the adequacy of the work and handle the necessary paperwork.

Operational and Maintenance Contract

Operational and maintenance (O&M) contracts are competitively bid and transfer part or all of the management responsibilities of a public enterprise to the private sector. Under this type of contract, the MPMW would retain public ownership of the water system, but the operational control, maintenance and staff management would be the responsibility of the private contractor through a multi-year agreement (typically 15 years). The private contractor would hold the water operator certifications required by the State to operate the system and would assume the public health risk associated with the delivery of domestic water to MPMW customers. In terms of capital improvements, these agreements typically require that the private operator execute projects associated with the maintenance of the water system for the life of the contract. While they can also include other major capital improvement needs, typical arrangements often leave the long-term planning and execution of these projects to the owner of the system. Under this option, the MPMW would be responsible for negotiating the terms and managing the contract, for developing the long-term capital improvement program to maintain and upgrade the infrastructure and for the implementation of the major improvement projects. User rates would be established by the contract fees and capital improvement needs and would be approved by the City Council.

The development of an O&M contract would offer a number of advantages. Foremost, it would relieve the MPMW from the management responsibilities associated with the operation, maintenance and operational staffing needs of the water system. It is important to note that the long-term planning responsibilities would be retained by the MPMW and performed by the engineering staff. With a negotiated long-term contract, the private operator would have the responsibility of operating the system at the negotiated costs. Water user rates would likely increase depending on the cost of the contract and the long-term capital improvement needs. Because the cost to manage and operate the water system would be determined by the private contractor, increases in rates associated with those services would have to be requested and justified by the private operator, not the municipality.

It is important to note that long-term O&M contracts for the provision of water services are not that common. Surveys of water and wastewater operations indicate that as of 2012, only 6% of municipal agencies hold contracts with private companies (Kishimoto *et.al*, 2015). In the Bay Area, there are not many private operators that currently manage and operate municipally owned water systems. Of the 26 BAWSCA member agencies, only the City of East Palo Alto’s water system is managed by a private company (American Water) through a long-term O&M Contract.

While long-term O&M contracts offer potential advantages, they are complex to negotiate and require oversight and management. The terms need to ensure that the water system is operated and maintained efficiently and oversight is required to hold the private contractor accountable to the agreed terms. Based on information provided by the WSMP Consultant, these types of long-term agreements typically result in a 12-18% profit margin for the private contractor. It can also be challenging to ensure that the infrastructure is operated and maintained in an efficient manner that does not lead to unnecessary wear and tear of the system during the life of the contract. For example, a private contractor may focus on improvements that make the operation of the system less costly, resulting in operational savings. Improvements that focus on improving and extending the life of the asset, however, are often not prioritized since these types of improvements may not result in cost savings over the term of the agreement.

There are also many studies show that private operation does not necessarily result in more efficient or less costly management. Empirical data and results from meta-analyses show that there is no support for cost savings associated with the private operation of water systems. The lack of savings could be due to the absence of competition and high cost of the transactions (Bel *et al*., 2010).

Water Lease

California Public Utilities law (Sections 10002 and 10006) allows municipalities to lease a utility for a minimum of 15 years to the highest bidder. Under this type of arrangement, the MPMW would retain public ownership of the water system, but forgo any responsibility for the management of the maintenance staff, O&M and capital improvement needs during the life of the lease. The lessee would hold the water operator certifications required by the State to operate the system and would assume the public health risk associated with the delivery of domestic water to MPMW customers. The MPMW would be responsible for negotiating the terms and managing the contract. Typical arrangements include a one-time payment at the beginning of the lease and an annual base rental for the duration of the contract term. The fees for water services would be owned and collected from the customers are by the lessee. Increases in the water rates, however, would be subject to the approval of the City Council and would be governed by California Constitution Article 10, Section 2 and Article 13D, Section 6 (Proposition 218). At the end of the lease, the City would be required to pay back the capital investments made to the infrastructure to the lessee at a depreciated value.

Leases are often driven by municipalities that are financially stressed. The cash from the one-time payment and annual rental fee is typically used to offset the costs of other municipal services. Other drivers involve the need for intense capital investment that may be too difficult to address due to any challenges associated with increases in water rates.

There are a number of advantages associated with lease agreements. First, they would result in a revenue stream for the City which could be used to supplement the General Fund. With a complete transfer of staff and O&M responsibilities, the MPMW would no longer have the responsibility of acquiring and managing staff or for the execution of capital improvement projects. In addition, the City would retain the allocation rights to the SFPUC Individual Supply Guarantee and have control of development within the City.

While these agreements offer potential advantages, they can be complex to develop and negotiate and require oversight and management. Similar to the disadvantages associated with O&M contracts, a lease agreement needs to include requirements that ensure that the water system is operated and maintained efficiently and oversight is required to hold the private contractor accountable to the agreed terms. Since the lessee would manage and implement capital improvements, the MPMW would have difficulty ensuring that the improvements actually extend the life of the asset, rather than a focus on operational changes that result in gains for the lessee. Also, the cost for capital improvements would be higher since private financing is more expensive than public. The higher cost of projects would be passed on to the customers.

Unlike a public municipality, private water companies are regulated by the California Public Utilities Commission. Since investor owned, the accountability is to the investors. Based on information provided by the WSMP Consultant, these types of long-term agreements typically result in a 12-18% profit margin for the private contractor. The combination of a high profit margin and the additional cost of private financing result in additional costs that are transferred to the customer.

As noted earlier, at the end of the lease, the MPMW would be required to reimburse the lessee for the capital improvements made to the system. The condition of the water assets at the end of the lease would therefore have to be assessed and agreed upon by the MPMW and the lessee. Since lease revenues are often used to supplement general funds, a municipality may not have the resources to reimburse the lessee for the investment to the assets. This situation may therefore result in the need to lease the water system again, which would result in an initial payment from the lessee which would then be used for the reimbursement. Lease agreements can therefore lead to a cycle of perpetual agreements. Lease agreements are not that common in the water industry. However, the Cities of Hawthorne and Commerce have had lease agreements with Cal Water since 1993 and 2003, respectively.

Private Ownership - Sale of the Water System

The MPMW has been operating as a public entity for the past 65 years. Under this option, the water assets would be sold to a private company. The MPMW would therefore no longer exist and the City would transfer all rights to the allocation of water supply from the SFPUC to the private company. The revenues from the sale of the water asset would supplement the General Fund. This option would reduce the number of services that the City offers.

While this option would relieve the City from the responsibilities associated with being a water purveyor, the City would forgo its water allocation. This means that the City would no longer have direct control over the planning for meeting water demand from future growth. The inability to plan for and ensure that future growth can have an adequate supply of water could have negative implications on the City's future development. In addition, as discussed earlier, the accountability of investor owned private companies is primarily to the investors. The need for profit margins therefore often results in higher rates to customers.

Financial Impacts

With additional resources, the MPMW would be able to implement a preventive maintenance program that would ensure the reliability and sustainability of the water system. The MPMW is fully funded through revenues received from the sale of water at user rates that are set and approved by the City Council. Water rates and other utility service charges, sewer and garbage, are governed by California Constitution Article 10, Section 2 and Article 13D, Section 6 (Proposition 218). Article 13D, Section 6 requires that the revenues collected from the fees not exceed the costs of providing the service; that they only be used for the purpose that they were collected for; that they do not exceed the proportional cost of service; and that charges be imposed only on property owners that use the service.

In May 2015, the MPMW completed a water rate study that made recommendations to increase rates. On July 21, 2015, the City Council approved the recommended water rates for the next 5 years, extending from FY 2015-16 through FY 2019-20. The key drivers for the rate increase were the following:

- Recovery from an operating deficit resulting from higher than expected SFPUC wholesale water rates and lower than anticipated water sales;
- Adjustment of the lower tier rate to reflect the true cost of water delivery;
- Revenue loss associated with the drought and lower water consumption; and
- Aim to restore the operating and capital reserve funds.

The addition of 4 positions would increase the personnel costs beginning in FY 2017/18 with the Phase 1 proposed hiring. In Phase 2, personnel costs would increase again with the additional 2 staff to be brought on in FY 2018/19 as shown in Table 2. Overall, the recommended positions would increase the MPMW expenses by approximately 1.7% in FY 2017/18 and FY 2018/2019 as shown in Table 3. The costs are based on budgetary, planning level estimates that include benefits, including retirement. It is important to note that the MPMW is a self-supporting enterprise. The revenues collected from customers through the sale of water are used to pay for all of the operating and capital costs. The Water Fund is therefore ultimately liable for the costs of all MPMW employees and their associated benefits, including retirement. Because the MPMW has been operating in a deficit and using reserves, the water rate structure approved in 2015 was designed to set the MPMW on a recovery mode and to begin accumulating the recommended operating and capital reserves. An additional increase to the expenses would therefore affect the sufficiency of the capital and operating reserves.

With the increase in staffing costs, the MPMW would continue to accumulate reserve funds, but would fall short of meeting the target recommended by the water rate Consultant. While it is acceptable for the reserves to fall below the target on a temporary basis, it is recommended that action be taken to set the MPMW on a recovery mode to meet the reserve fund target in the future years. This action would therefore require the development of another water rate study to assess the impact of the staffing levels and also would include any changes in recommended projects to the Capital Improvement Program based on the capital improvement recommendations from the Water System Master Plan.

Table 2 – Estimated Additional Staff Costs

Positions	Phase 1 FY 2017-18	Phase 2 FY 2018-19
New Senior Water System Operator New Water System Operator I/II	$225,000	
New Water Quality Specialist New Water System Operator I/II		$225,000
	Phase 1 and Phase 2 Total	**$450,000**

Note: Staff costs are based on estimated budgetary numbers.

Table 3 – Proposed Increase in Expenses from Estimated Additional Staff Costs

	Phase 1 FY 2017-18	Phase 2 FY 2018-19
Expenses	$13,600,000	$13,600,000
Additional Staffing Cost	$225,000	$225,000
% Increase to Expenses	%1.7	%1.7
Total % Increase	**3.3%**	

Next Steps

For the past 65 years, the MPMW has been serving its customers with safe drinking water and fire suppression services at reasonable costs. Based on the evaluation of a number of management options, Staff requests that the City Council provide feedback on the proposed strategy, which consists of staff augmentation and retaining the public management of the MPMW. With additional staff, the MPMW would be able to implement a preventive maintenance program to improve the reliability of the water system while avoiding costly repairs associated with unexpected failures resulting from the inability to implement effective maintenance programs. Also, under this option, the City would continue to retain the water supply allocation from the SFPUC and have direct control of development in the areas served by the MPMW.

While the recommendation from the WSMP is for the addition of 4 maintenance workers, staff is recommending a multi-year phased approach. Phase 1 would include the addition of 2 staff in the proposed FY 2017-18 budget while continuing to explore the feasibility of contracting out other specific maintenance tasks. Phase 2, which could include the addition of 2 more staff, would be considered at a later time, depending on the level of contracting services and the staffing needs.

Impact on City Resources

The proposed staffing level changes would temporarily impact the MPMW's capital and operating reserve funds until new water rates are adopted as described above.

Environmental Review

There is no environmental review required for this action.

Public Notice

Public Notification was achieved by posting the agenda, with the agenda items being listed, at least 72 hours prior to the meeting.

Attachments

A. Figure – MPMW Service Area, 2017
B. Figure – Water Providers Within and Surrounding Menlo Park
C. Table – WSMP Appendix 10-A, Staffing Level Assessment Operation and Maintenance Tasks
D. Table – Staffing Level Comparison to Other Municipalities

References

Kishimoto, S., Lobina, E. and Petijean, O. 2015. Our public water future, The goblal experience with remunicipalisation. *Transnational Institute, Public Services International Research Unit, Multinationals Observatory, Municipal Services Project and European Federation of Public Service Unions.*

Bel, G.,.Fageda, X., and Wamer, M.E. (2010). Is private production of public services cheaper than public production? A meta-regression analysis of solid waste and water services. *Journal of Policy Analysis and Management*. (29) 3, 553-577.

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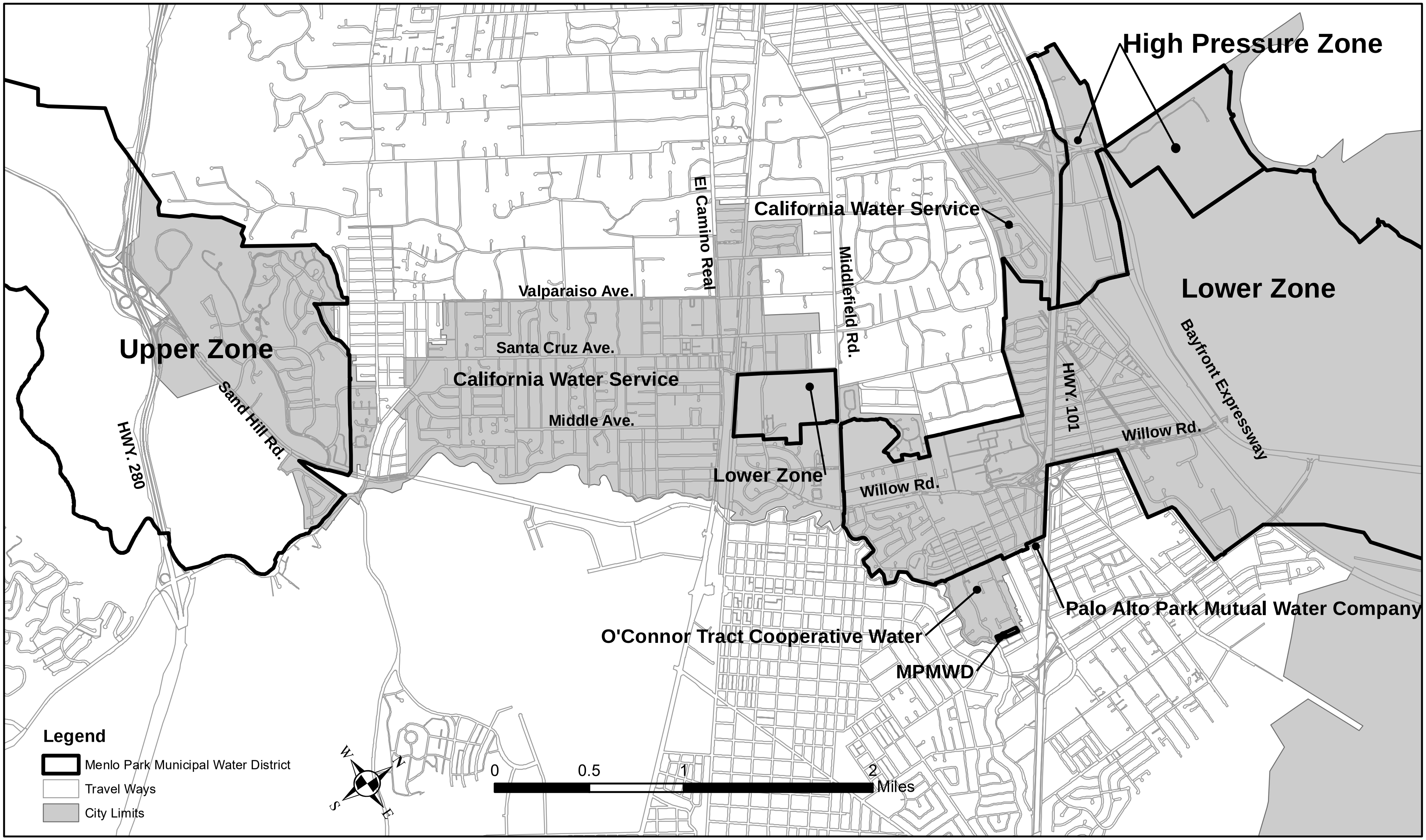
Water Districts Within the City of Menlo Park



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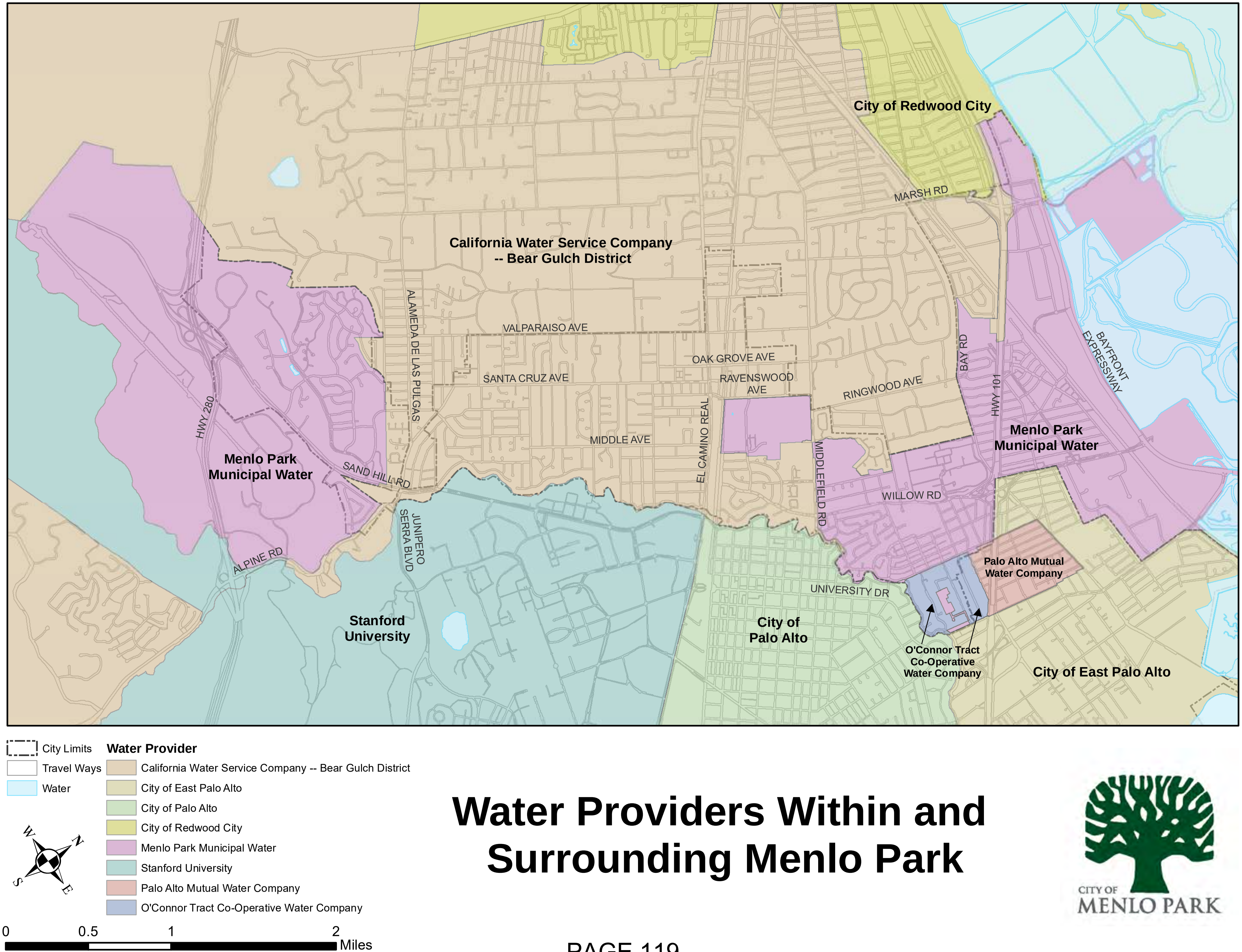

Water Providers Within and Surrounding Menlo Park

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Water System Mater Plan Appendix 10-A, Staffing Level Assessment Operation and Maintenance Tasks

Task	Assumptions	Estimated Annual Hours	
Utility Marking	40 per month, 2 a day for 20 days a month, 2 hrs each with travel	960	9%
Work Order Documentation	1 hours a day for 20 days a month	240	2%
SFPUC Meter Reading	once a month, 3 hours with travel	36	0%
Meter Maintenance	12 meters per month, 4 hours each	576	5%
Meter/Service Replacements	10 per month, 2 employees 8 hours each	1920	18%
Pump Station Inspections	once a day, 20 days a month for one hour	240	2%
Pump Station Maintenance	8 hours a month	96	1%
Generator Inspection and Testing	6 hours a month	72	1%
Reservoir Inspections	once a day, 20 days a month for one hour	240	2%
Reservoir Maintenance	4 hours a month	48	0%
Cross-Connection Testing	50 units per year, 1.5 hr per unit to test and document	75	1%
PRV Inspections	1.5 hours per day with travel, 20 days a month	360	3%
PRV Maintenance	6 hours every 6 months	12	0%
Hydrant Inspection	1.5 a day at 1.2 hours for 20 days a month	288	3%
Hydrant Testing	3 hydrants a week at 3 hours each with documentation	432	4%
Hydrant Replacement/Repair	1.5 per month, 2 employees at 8 hurs each	288	3%
Dead-end Flushing	5 a month at 4 hours each with documentation	240	2%
Valve Exercising & Maintence	7 a week at 1 hour each	336	3%
Valve Repair/Replacement	1 every other month, 2 employees at 4 hours each	48	0%
Water Quality Sampling & Documentation	15 hours a week	720	7%
Certification Training	16 hours a year for 5 employees	80	1%
Safety and Computer Training	8 hours a month for 5 employees	480	4%
Updates to ERP/ Annual Training Drills	8 hours a year for 5 employees	40	0%
Repair Water System leaks	7 per month at 4 hours each	336	3%
Regulatory & Monthly Reporting	6 hours a month	72	1%
Staff & Field Meetings	20 hours a month for 2 employees	480	4%
SCADA Monitoring	8 hours a month	96	1%
Meter Rereads/Shut-offs	80 per month at 1 hour each	960	9%
New Construction Inspections	8 hours a month	96	1%
Inventory and Purchasing	3 hours a week	144	1%
Field Equipment and Vehicle Maintenance	5 hours a month	60	1%
Coordination with Subcontractors	3 hours a week	144	1%
Vegatation Maintenance (Meter boxes and facilities)	30 per month at 1.5 hour each	540	5%
Customer Service	4 hours a week	192	2%
Performance Reviews	8 hours once a year	8	0%
	Total	10955	

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Table - Staffing Level Comparison to Other Agencies

Utility	Location	Population Served	No. of Water Connections	Water Staff	No. of Water Connections per Staff
MPMWD (Existing)	Menlo Park, CA	16,100	4,202	3	1,401
MPMWD (Proposed)	Menlo Park, CA	16,100	4,202	7	600
Neighboring BAWSCA Agencies – Similar Size (Based on No. of Water Connections)					
East Palo Alto	East Palo Alto, CA	28,155	3,752	5	750
Hillsborough	Hillsborough, CA	11,260	3,880	9	431
Other Agencies - Similar Size (Based on No. of Water Connections)					
Carpinteria Valley Water District	Carpinteria, CA	16,050	4,293	6	716
Lomita	Lomita, CA	20,300	4,176	6	696
Nipomo Community Services District	Nipomo, CA	12,512	4,284	5	857
Trabuco Canyon Water District	Trabuco Canyon, CA	14,900	3,962	7	566
Neighboring BAWSCA Agencies – Not of Similar Size (Based on No. of Water Connections)					
Redwood City	Redwood City, CA	87,059	22,997	22	1,045
Mountain View	Mountain View, CA	76,413	17,857	21	850
Palo Alto	Palo Alto, CA	66,152	19,863	21	945
San Bruno	San Bruno, CA	43,798	9,524	14	680
Burlingame	Burlingame, CA	30,282	9,137	15	609
Millbrae	Millbrae, CA	21,532	6,555	7	936
Mid-Peninsula Water District	Belmont, CA	26,730	7,974	13	613

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